Graduate School ETD Form 9
(Revised 01/14)

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis/Dissertation Acceptance

This is to certify that the thesis/dissertation prepared

By James D. Osborne Jr.

Entitled
Spectroscopic and Chemometric Analysis of Automotive Clear Coat Paints by Micro Fourier Transform Infrared Spectroscopy

For the degree of Master of Science

Is approved by the final examining committee:

John V. Goodpaster

Nicholas Manicke

Robert E. Minto

To the best of my knowledge and as understood by the student in the *Thesis/Dissertation Agreement. Publication Delay, and Certification/Disclaimer (Graduate School Form 32)*, this thesis/dissertation adheres to the provisions of Purdue University's "Policy on Integrity in Research" and the use of copyrighted material.

Approved by Major Professor(s): John V. Goodpaster

Approved by: Christine Picard 07/18/2014

Head of the Department Graduate Program Date

SPECTROSCOPIC AND CHEMOMETRIC ANALYSIS OF AUTOMOTIVE CLEAR COAT PAINTS BY MICRO FOURIER TRANSFORM INFRARED SPECTROSCOPY

A Thesis

Submitted to the Faculty

of

Purdue University

by

James D. Osborne Jr.

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

August 2014

Purdue University

Indianapolis, Indiana

To my wife and children for all your love and support as I worked toward fulfilling my goal of receiving a master's degree, I thank you and love you. To my friends: Jeff, Jon, George, and Darrius for your help, your support and your years of friendship; thank you.

ACKNOWLEDGEMENTS

I would like to thank Dr. Jay Siegel and Dr. John Goodpaster for being my advisors during my graduate career. Your mentorship and support have been invaluable to me and I know I would not have completed this program were it not for that support and the advice I received from the two of you.

What also like to thank my classmates, the first graduate class for forensics at IUPUI, the friendships I have made will always be remembered and the help and support I received will always be appreciated.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF ABBREVIATIONS

AHC	Agglomerative Hierarchical Cluster
ANOVA	Analysis of Variance
ATR	Attenuated Total Reflectance
DA	Discriminant Analysis
FT-IR	Fourier Transform Infrared
HeNe	Helium Neon
IR	Infrared
KRS-5	Thallium Bromoiodide
MIR	Multiple Internal Reflectance
NHTSA	National Highway Traffic Safety Administration
OEM	Original Equipment Manufacturer
PC	Principal Component
PCA	Principal Component Analysis
UV-VIS	Ultraviolet Visible
VOC	Volatile Organic Compounds
ZnSe	Zinc Selenide
ZPD	Zero Path Distance

ABSTRACT

Osborne, James D. M.S., Purdue University, August 2014. Spectroscopic and Chemometric Analysis of Automotive Clear Coat Paints by Micro Fourier Transform Infrared Spectroscopy. Major Professor: John V. Goodpaster.

Clear coats have been part of automotive field paint finishes for several decades. Originally a layer of paint with no pigment, they have evolved into a protective layer important to the appearance and longevity of the vehicle's finish. These clear coats have been studied previously using infrared spectroscopy and other spectroscopic techniques. Previous studies focused on either all the layers of an automobile finish or on chemometric analysis of clear coats using other analytical techniques. For this study, chemometric analysis was performed on preprocessed spectra averaged from five separate samples. Samples were analyzed on a Thermo-Nicolet Nexus 670 connected to a Continuμm™ FT-IR microscope. Two unsupervised chemometric techniques, Agglomerative Hierarchical Clustering (AHC) and Principal Component Analysis (PCA), were used to evaluate the data set. Discriminant analysis, a supervised technique, was evaluated using several known qualifiers; these included cluster group from AHC, make, model, and year. Although discriminant analysis confirmed the AHC and PCA results, no correlation to make, model, or year was indicated.

CHAPTER 1. INTRODUCTION

1.1 Introduction

The purpose of this study was to determine if Fourier Transform Infrared (FT-IR) spectroscopy combined with chemometric analysis could discriminate among different automotive clear coats based on class, year, make, or model. Different sample analysis techniques were employed to develop a routine FT-IR method. Data from the final method was evaluated using different chemometric analysis techniques including Agglomerative Hierarchical Clustering (AHC), Principal Component Analysis (PCA), and Discriminant Analysis (DA). The data was evaluated to determine the region of the FT-IR spectrum which had the highest variability and therefore greatest ability to discriminate. Finally the results of standard library searching were compared to the chemometric results.

1.2 Chemometric Techniques

Chemometric analysis has become a common tool in scientific research including forensic and investigative sciences. Chemometric analysis is a means to look for patterns or groupings of data not visible to the naked eye. It is particularly useful with spectroscopic techniques such as Ultraviolet Visible (UV-VIS)[1], Near Infrared (NIR), Fourier Transform Infrared (FT-IR)[2], and Raman.[3] Chemometric techniques have been applied to the analysis of documents, inks, fibers, and a host of other materials.[2,4] The theory and formulas surrounding chemometric analysis have been around since the beginning of the 20th century. For example, Pearson described a dimension reduction in data display technique in 1901. Algorithms to describe principal component analysis were developed by Hotelling in 1933 and the Mahalanobis distance equation, named for its creator, was introduced in 1936.[5] However, it wasn't until the computer age that it became possible to use them routinely. This type of research can be used to address accuracy and reliability as per Recommendation 3 of the National Academy of Sciences report on strengthening forensic science[6] and also as the reliability and relevance of data as outlined in the Supreme Court case *Daubert versus Merrell Dow Pharmaceuticals (1993)*.[7]

There are two general types of chemometric analysis, supervised and unsupervised. This study used two forms of unsupervised analysis, AHC and PCA followed by a form of supervised analysis, discriminant analysis. These were applied to the data set following preprocessing.

1.3 Preprocessing of Analytical Data

Preprocessing of the data is an important step in chemometric analysis and is one of the "six habits of an effective chemometrician".[8] It reduces if not eliminates random and systemic noise present in the raw data. In the case of infrared spectroscopy, systemic noise would include such things as absorbance due to water vapor or constructive/destructive interferences. Sample preprocessing methods include smoothing, baseline correction, normalization, and mean centering.[5, 8]

Smoothing is a function used to reduce random noise. The downside of smoothing is that if done incorrectly can obscure detail in the spectra and skew peaks.[8] There are numerous algorithms used to smooth data; mean smoothing, running mean, running median, running polynomial, etc. Mean smoothing, a simple form of smoothing, operates by selecting a window width n. Starting at the beginning of the data set it averages the first n data points, often referred to as elements. The algorithm then takes the $n+1$ to $2n$ elements and averages that set. It progresses through the data set in a similar manner. The running mean smooth and running median smooth are similar in that the window is moved across the data set one element rather than one window width at a time. The difference is a running mean uses the mean of the window while running median uses the median of the selected window width. The issue with these algorithms is that they tend to distort the ends of the data set. A running polynomial smoothing algorithm (i.e., the Savistky-Golay algorithm) is the most common in spectroscopic data packages. It uses a low order polynomial to fit the points in the window. This method provides a more accurate smooth and also does not distort the ends of the data sequence.[5, 8]

Baseline correction adjusts the minima of the spectra back to the origin, and if done correctly, can correct for some of the effects of constructive/destructive interference, light dispersion, or absorption effects due to elemental carbon. However, done incorrectly it can remove important details and skew peaks.[5, 8]

Normalization is used to remove systematic variations due to differences in sample thickness or density. It does this by adjusting the range of the data set from minimum to maximum to be the same across all the data sets. This can mean normalization to unit area, unit length or to a maximum intensity of a set value. In infrared spectroscopy data is normalized to a maximum intensity that is set equal to one.[8, 9]

Sample weighting, multiplying each element in a sample's data set by a constant, is done to influence how a sample behaves in a mathematical model. It is similar to normalization but has different criteria for defining the constants. An example is giving more weight to the data generated by an experienced analyst versus that of one with limited experience.[8, 9]

Before beginning data analysis all preprocessing methods need to be evaluated to determine how applicable they were to this experiment. Of these, baseline correction, normalization, and smoothing were deemed appropriate for this project.

1.4 Hierarchical Cluster Analysis

One form of unsupervised data analysis is Hierarchical Cluster Analysis (HCA). Unsupervised data analysis classifies data into subgroups when no prior knowledge of the data set is known. This method of data reduction generates a two-dimensional representation of the data called a dendrogram. Dendrograms allow the data to be viewed in such a manner that patterns can be recognized visually. Using a dendrogram, natural grouping can be visualized and hypotheses developed for future testing. The data is presented as high-dimensional row space which is a vector space generated by the rows of the data matrix viewed as vectors. The distance in vector space between groups can be calculated by different means. The distance between groups is used as a measurement of dissimilarity.[8] One approach to determining this distance is by calculating a Euclidean distance. Derived from the Pythagoras' theorem, it is calculated using equation 1.1 for objects in two dimensional space. The two points are represented by their (x,y) coordinates and $d_{(x.y)}$ is the distance between them. The smaller $d_{(x.y)}$ the closer the points are in space.[10]

$$d_{(x.y)} = [(x_1 - y_1)^2(x_2 - y_2)^2]^{1/2}$$ Equation 1.1

Another common means of calculating the distance between groups is to use the Mahalanobis distance (Equation 1.2). Unlike Euclidean distance, Mahalanobis distance has units based on standard deviation instead of distance units. Mahalanobis distance units can be converted back to Euclidean distance by dividing by the standard deviation. Mahalanobis distance is therefore a better indication of how far a point is from the normal distribution of the data set. The only additional term in the equation that differs from that of the Euclidian distance is the "C" term which is the variance-covariance matrix of the variables.[9]

$$d_{(x.y)} = [(x - y)'C^{-1}(x - y)]^{1/2}$$ Equation 1.2

Hierarchical clustering can be done by two different means. Agglomerative hierarchical clustering starts with every data point being its own cluster. It then creates linkages based on the distance formula used to build clusters of related data sets, clusters, until all data sets are linked.[8, 10] The data sets most alike are grouped first and then the smaller groups are linked to other groups based on similarity. In the end all the groups of the data set will be linked. Divisive hierarchical clustering works in the opposite manner. Divisive clustering initially assumed all data as part of one group and then divides it into subgroups based on similarities (distance) until all the subgroups are broken back down into individual data sets.[11, 12] Both types of clustering can be calculated using either Euclidean distance or Mahalanobis distance.

Another variable in hierarchal clustering is how the linkages are determined. Different methods have been developed to make these linkages. These methods include average linkage, centroid method, Ward's method, single linkage, and complete linkage. Average linkage uses the average distance between pairs of observations to determine the distance from one cluster to the other. This method tends to join cluster for small variances, but is slightly biased toward producing clusters with equal variance. The centroid method uses a squared Euclidean distance between the means of different clusters. It is more robust than other hierarchal methods, but may not perform as well as Ward's or average linkage depending on the data set. Ward's method is a minimum variance method that uses the ANOVA sum of squares between clusters added over all their variables. Ward's method joins clusters with a small number of observations, but is strongly biased toward trying to create clusters with the same number of observations. It is also highly sensitive to outliers. Single linkage uses a minimum distance between an observation in one cluster and an observation in another. Single linkage sacrifices performance with regards to compact clusters in return for the ability to detect irregular and elongated clusters. Single linkage also tends to cut off the tails of distributions before the separation of the main clusters. Complete linkage, sometimes referred to as furthest neighbor, and uses a maximum distance between an observation in one cluster and an observation in a second. Complete linkage is strongly biased in that it tends to produce clusters with roughly equal diameters and can be distorted severely by moderate outliers.[8, 11]

Although hierarchal clustering is and unsupervised technique, it still requires the analyst to evaluate the data. The analyst has to choose the style of clustering and the linkage method to use for processing and at the end, through evaluation of the data, decide how many groups or clusters truly are present. In the example shown in Figure 1.1, the analyst would need to evaluate the data to determine if there are six, four, three or two real clusters based on criteria related to the data set. The length of the lines representing each sample indicates the distance from its neighbors. Determining the number of relevant groups can be done visually or based on other results such as spectral features or additional chemometric analysis such as PCA.

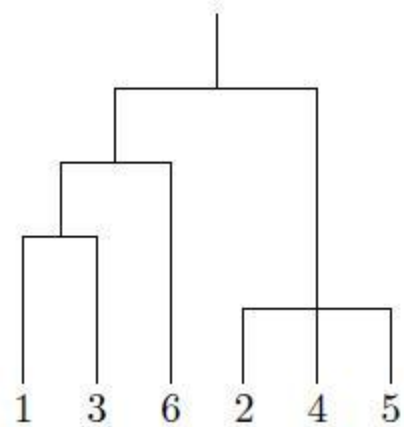


Figure 1.1 Generic Hierarchical Cluster Analysis (HCA) diagram

1.5 Principal Components Analysis

Humans can only visualize data in a few dimensions; typically three or less. Principal component analysis is a mathematical method of reducing a data set with numerous variables into fewer dimensions. It does this by describing the data set using a new set of variables called “factors”. The axes are then redefined based on these factors to create new principal component (PC) axes that allow the data to be described in fewer dimensions and therefore allow for human pattern recognition.[8]

By definition, the first PC accounts for the largest portion of the variability in the data set. This new axis is a line through the centroid of the data. The second PC is orthogonal to the first and accounts for the second highest portion of the total variance. Subsequent principal component axes are orthogonal to previous PCs and account for less of the remaining variance with each iteration.[5, 8, 11] Only the significant PCs, as reflected by their eigenvalues, are retained while remaining eigenvalues representing noise should be ignored. If a correlation exists between the original variables, then only the first few PCs should account for the majority of the variance (<90%). This can be visualized by scree plot. A scree plot, named for his resemblance to the scree material at the base of a rock cliffs, displays eigenvalues versus factor number. A sudden change in slope is an indication of the end of the significant principal components.[11, 12]

With today's computer software, data points can be plotted against the different principal component axes to give the analyst a visual representation. This visual representation of the data points in a simulated three-dimensional space can be enhanced with different symbols and colors such that individual groups can readily be identified.

1.6 Discriminant Analysis

Discriminate analysis (DA) sometimes referred to as linear discriminate analysis or canonical variates analysis [5] is a supervised statistical analysis technique where information related to the sample is needed prior to the start of any calculations. Using the known classes as criteria, new axes are calculated that best separate the data set into groups. These new axes are linear combinations of the original features.[5] DA differs from PCA in that it is supervised (i.e., it is data classified rather than feature classified). For DA to function, the number of random samples must be higher than the number of variables.[12] PCA is often used to reduce the number of variables needed to describe the data set prior to DA.[5] Other known variables that describe the data (year, make, model, etc.) can also be used as possible variables.

Using the known variables DA generates a rule or set of rules by which a data point can be classified as belonging to a specific population. Four methods are available to generate the rule or rules, the Mahalanobis distance rule, the likelihood rule, linear discriminator rule, and posterior probability rule.[13] The software used for this research used the Mahalanobis distance rule.

Following the generation of the discriminate rule or rules, the accuracy of the classification can be estimated. Different methods have been described to estimate the accuracy. These include the resubstitution method, cross validation method, and the hold out method.[13]

1.7 Fourier Transform Infrared Analysis

Infrared radiation is considered that region of the electromagnetic spectrum from 0.75 to 200 µm. The mid-infrared region is a subset of this region and refers to the region from 2.5 to 50 µm. Note that many older references to infrared data use units of microns or micrometers rather than wavenumbers. Wavenumbers are expressed in reciprocal centimeters (cm-1 or v) and can be interconverted with microns.[14]

Light in the infrared region does not have as much energy as visible or ultraviolet light. For example; photons in the infrared region cannot excite electrons to higher electronic states. However, infrared light does has sufficient energy to excite the molecular bonds to higher vibrational states. For absorption of infrared light to occur the frequency of the infrared light must match the vibrational frequency of a particular bond and a dipole moment must exist. Because different types of chemical bonds absorb different frequencies of infrared light, an infrared spectrum can be used for structural elucidation.[14, 15]

Major components of an FTIR spectrometer are shown in Figure 5.[16] In the FTIR system infrared light is collimated and sent to the beam splitter of the Michelson or Mattson interferometer. The beam is divided so that part of the beam is directed to a moving mirror and the rest toward a stationary mirror. Reflected light recombines and undergoes interference. This recombined beam of light is directed to the sample and onto the detector.[17] A helium-neon (HeNe) laser undergoes the same processing and serves as a reference for the position of the moving mirror. Adjustments are made every time the center burst is seen, which is at the zero path distance (ZPD). The signal from the detectors is converted from analog to digital and stored in computer memory. Scans are averaged to improve the signal-to-noise ratio.[16]

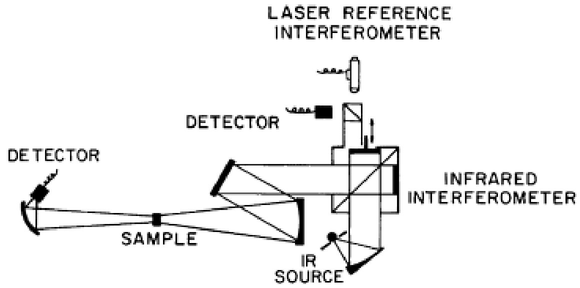


Figure 1.2 Diagram of a FT-IR spectrometer with a Michelson interferometer

Fourier transform infrared instruments offer several advantages over dispersive instruments. The two most significant advantages are higher signal-to-noise ratios for similar analysis times and higher frequency accuracy for spectra collected over a wide range. The signal-to-noise improvement is due to two different aspects. First, the full spectrum of infrared light reaches the detector at once not just a small bandwidth of light as in dispersive instruments. This is referred to as the multiplex or Fellgett's advantage. The second aspect contributing to the signal-to-noise increase is a high optical throughput of the FT-IR instrument, known as Jacquinot's advantage. This results from the lack of any slits in an FT-IR to reduce the amount of light that strikes the detector. Improved spectral accuracy is due to the use of the laser reference. This is sometimes referred to as Connes' advantage.[15, 16]

Although many different types of experiments can be done using FT-IR, only normal transmission and Attenuated Total Reflectance (ATR) were used for this work. ATR, once referred to as Multiple Internal Reflectance (MIR), involves an infrared beam of light passing perpendicular to the short face of a trapezoid or parallelogram shaped crystal then reflecting along the inside of the crystal until it passes out the other end (Figure 1.3).[17]

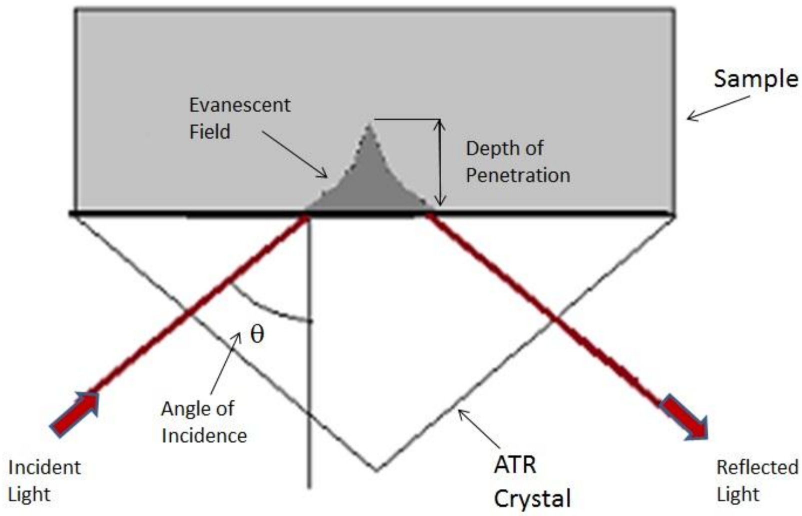


Figure 1.3 Attenuated Total Reflectance (ATR) diagram

The internal reflection occurs because light strikes the internal surface at an angle greater than the critical angle of the crystal material being used. The critical angle for a crystal material is determined using the following formula.

$$\theta_C = \sin\theta^{-1}\left({}^{n_2}/_{n_1}\right) \qquad \text{Equation 1.3}$$

Where n_1 is a refractive index of the denser medium and n_2 is the refractive index of the rarer medium. Five materials are commonly used in ATR for FTIR analysis: silicon, KRS-5, ZnSe, germanium, and diamond.[17] When samples are in firm contact with the crystal, light passes between the crystal/sample interface and interacts with the sample producing a spectrum. Two major factors, surface area and depth of penetration, determine the amount of absorbance. Surface area is determined by the area of the crystal that is in contact with the sample. The depth of penetration, d_p, can be calculated using the following equation:

$$d_p = \frac{\lambda}{2\pi n_1(\sin^2\theta - n_{21}{}^2)^{1/2}} \qquad \text{Equation 1.4}$$

Where n_1 is the refractive index of the ATR crystal material and n_{21} is the ratio of the samples refractive index versus that of the ATR crystal. The angle of incidence, θ, is the angle of the light at the interface of the crystal and the sample. Depth of penetration is therefore proportional to wavelength and inversely proportional to refractive index. This causes two phenomena; the first is that the fingerprint region of the spectrum is greatly enhanced making it necessary to use a correction function to convert the spectrum to a transmission or absorbance format. The second is a small degree of depth profiling can be achieved by using crystals of different refractive indices.[16, 17]

Infrared microscopy allows for most FT-IR techniques to be used at the microscopic level. This can include fibers, particles, and even liquids. For fibers and particles, the sample must be held in place during the analysis. For transmission experiments, this can include compression cells or anvil cells. The cells can either simply hold the sample or flatten the sample to a thickness more appropriate for the experiment. Detectors for FT-IR microscopy are often liquid nitrogen cooled and are two orders of magnitude more sensitive than the standard room temperature detectors. An issue with the cells is that if an air space is present, the IR beam can reflect between the windows of the cell creating constructive/destructive interference which appears as a sine wave under the actual IR spectrum. Although it is possible to correct this sine wave through baseline correction, is more appropriate to correct the sample preparation. A limitation of IR microscopy is that the sample size must not be too small. Samples which are smaller than 20 μm will diffract the beam causing signal loss and distortion.[18]

For this work, initial assays used standard transmission techniques such as thin-films of possible wax contaminants and ATR was evaluated before deciding on using FT-IR microscopy as the primary method.

CHAPTER 2. AUTOMOTIVE COATINGS

The National Highway Traffic Safety Administration (NHTSA) reported approximately 5.3 million automobile accidents in 2011. [19] Although the NHTSA does not maintain statistics for accidents involving hit-and-run, most states do collect this data. For 2011, Indiana recorded over 22,000 hit-and-run accidents. Of these 28 involved a fatality and 1825 involved injury. [20] For these types of cases forensic evidence is often necessary to tie a suspect to the crime scene.

For most auto accidents paint evidence is found at the scene. As the clear coat is the outermost layer it is the most likely to be transferred or lost when an object is struck. The fragments may be found on the ground at the scene or on another car, a fixed object, or person. Past research has primarily focused on the pigment layer, while only a few studies focused on the clear coat. Recently more emphasis has been focused on the clear coat layer using different analytical techniques while including chemometric analysis of the data.

Most of today's automobiles have a painted surface of over 100 µm deep and composing up to five different layers. These different layers are shown in Figure 2.1.[21]

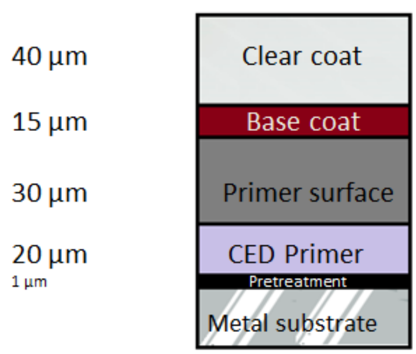


Figure 2.1 Automobile surface coatings

The pretreatment layer, the thinnest layer, prepares the substrate for additional coats. The cathode epoxy deposit primer layer is the actual backbone of the process. The primer surfacer fills in minor imperfections. The basecoat is the actual pigment layer, and the final layer is a clear coat sometimes referred to as the topcoat.

Prior to 1970 most automobiles were painted with solid color paint as the outermost layer. [22] Initial original equipment manufacturer (OEM) clear coats were the same acrylic-based material as a color layer, but with no pigment. Over time the clear coat layer evolved into two major groups. One a single application (1K) consisting of acrylic resins and melamine cross-linkers preferred in the United States. The other a two component (2K) system consisting of an acrylic resin with hydroxyl (OH) functional groups and the reactive polyurethane cross-linker which was preferred in Europe. [22] Application of basecoat and clear coats accounted for the majority of volatile organic compound (VOC) emissions by the automobile manufacturing industry. Environmental concerns have led to the manufacturers moving from organic solvent application to aqueous-based and powder coat technologies. Additionally a new 1K type clear coat using carbamate functional groups has become popular in the United States.

Currently seven different types of clear coats are used in the automobile manufacturing industries of the United States and Europe. The most common type in use today is the one component (1K) acrylic melamine topcoat. The reaction to generate this topcoat is shown in figure 2.2.[22] Although not shown in the reaction scheme, the acrylic functional group will lead to an ester carbonyl group which will exhibit bands in the infrared near 1735 cm^{-1} for the carbonyl group and carboxyl C-O linkages between 1300 cm^{-1} and 1050 cm^{-1}.[14] This polymer would also exhibit bands associated with the amines on the melamine and additional ether linkages for any unreacted branches of the alkoxylated melamine.

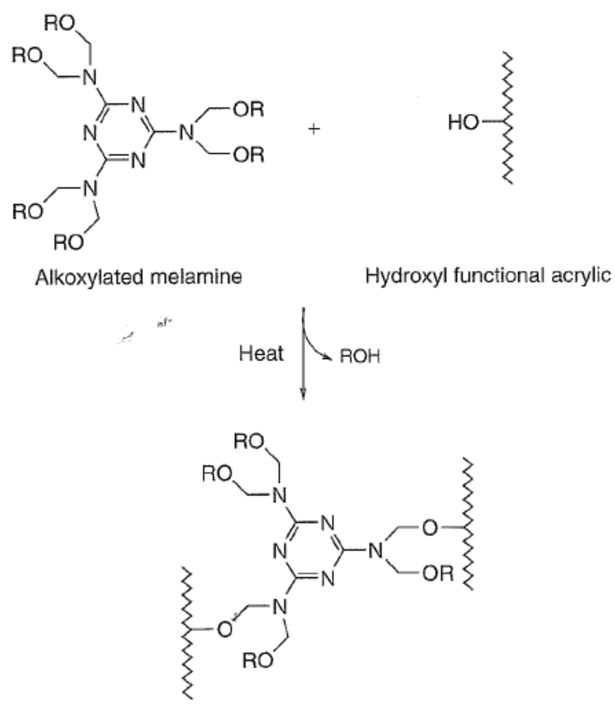


Figure 2.2 Reaction scheme for acrylic melamine topcoat

A variation of this type is the acrylic melamine silane topcoat. These topcoats were introduced in the 1990s and use silane groups on the polyol chains to generate siloxane groups in the final product. Due to the edge and scratch resistance of these clear coats they are gaining popularity in both the US and Europe.

A newer single coat (1K) clear coat is a carbamate melamine base polymer system being used almost exclusively in the United States (Figure 2.3).[22] The infrared spectrum of this polymer should exhibit a carbonyl group somewhere between the 1735 cm^{-1} and 1680 cm^{-1} due to the influence of the secondary amine group on the ester carbonyl. The ether linkages due to the ester group and any unreacted branches of the alkoxylated melamine will be in the region of 1300 cm^{-1} and 1050 cm^{-1}.

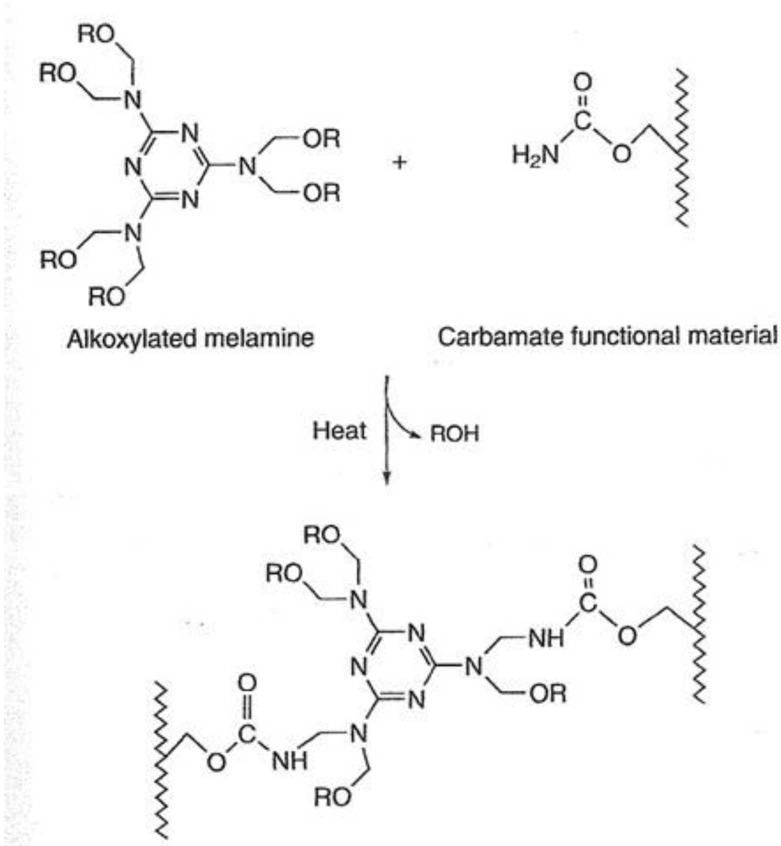


Figure 2.3 Reaction scheme for carbamate melamine topcoat

Two related types are the 1K and 2K polyurethane-based clear coats. These types use the reaction of polyisocyanate with malonate esters or dimethyl pyrazole in the 1K form and polyol with a hydroxy group in the 2K application. These types are widely used in the European car industry (Figure 2.4).[22] Polymers resulting from reactions using polyisocyanate reactants should exhibit two types of carbonyl bands due to the different functional groups associated with them.

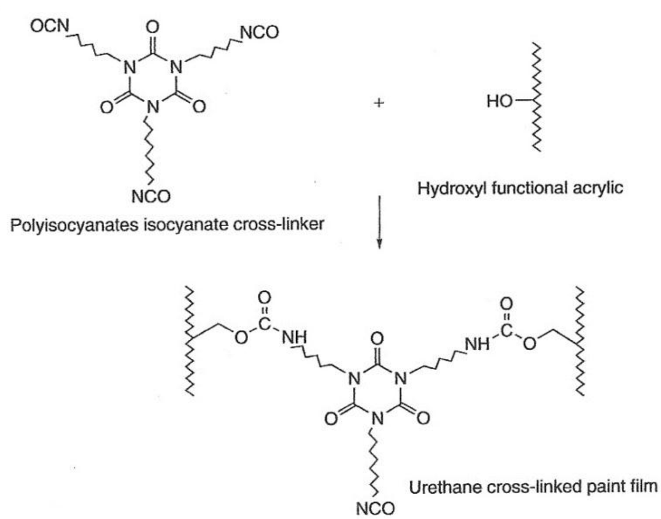


Figure 2.4 Reaction scheme for carbamate polyurethane topcoat

An epoxy type, used mostly by Japanese carmakers, uses the cure reaction of an aliphatic polycarboxylic acid with a glycidyl functional acrylic polymer. This results in a β-hydroxy polyester (Figure 2.5).[22]

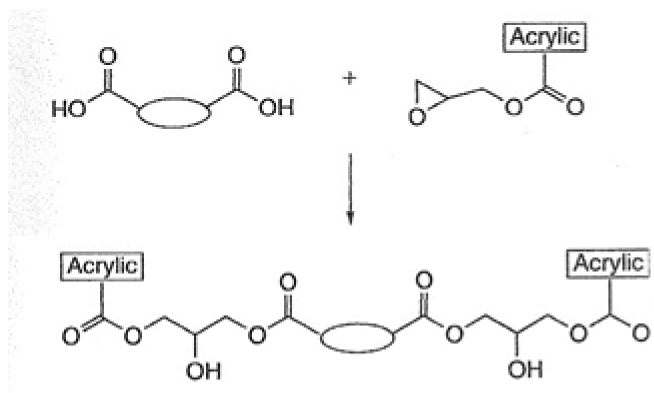


Figure 2.5 Reaction scheme for β-hydroxy polyester

Water-based clear coats were first introduced in 1990 by Opel. Initially a dispersal of glycidyl methacrylate acrylic powder clear coat in water, it has evolved into a solvent free system of an acrylic polyol, melamine, and a blocked isocyanate introduced in 1997 by DaimlerChrysler.[22] These are applied as a slurry containing a bimodal mixture of large and small particles with the larger particles being approximately seven time larger than the smaller particles. Each particle contains both reactants for the polymer. As the temperature is raised the water is driven off and the isocyanate is unblocked allowing the reaction to occur as shown in Figure 2.1.[23]

The most environmentally friendly and efficient technology is a powder clear coat. It uses no organic solvents, has a transfer efficiency of greater than 90%, and there is no waste. Several BMW manufacturing lines in Germany use this technology for clear coats, but it hasn't yet been adopted by other auto manufacturers. The only US vehicle manufacturer using powder based clear coats is Harley-Davidson.[22]

CHAPTER 3. DATA ANALYSIS

3.1 Materials and Methods

Data collection was conducted in three distinct phases. The first phase was a brief investigation into possible interference from aftermarket polishes and waxes. The second phase was method development using different accessories of the FT-IR spectrometer and optimization of the final method. The last phase was analysis of the sample set using the final method.

Waxes and polishes are used both for aesthetic and protective purposes. They are applied as waxes or sprays following washing of the exterior of a vehicle. Because planned experiments initially used a surface FT-IR technique, an understanding of the possible interference from these materials needed to be examined. Three different brands of waxes and polishes were analyzed as thin films on 24 x 4 mm potassium bromide discs. A small amount of the sample was placed on one window and then pressed flat with a second window. The windows were separated by sliding the top window to one side until the two windows separated. Spectra were generated by averaging 128 scans taken at a resolution of 4 cm^{-1}. Spectra where evaluated against commercial FT-IR libraries.

The second phase of data analysis was method development. Clear coat samples were isolated and analyzed using three different FT-IR spectrometer techniques. The first two techniques utilized single bounce attenuated total reflectance (ATR) units that were designed to fit into the main sample compartment. Once in place the units sealed against the walls of the compartment and a chip identified the unit to the computer. The computer then loaded the appropriate instrument settings. The first ATR method used a Thermo Scientific Omni-sampler accessory outfitted with the germanium window (Figure 3.2). The second used a Thermo Scientific Smart Orbit Diamond single bounce ATR (Figure 3.3). The instrument parameters included a correction for attenuated total reflectance.

This is done rather than advanced attenuated total reflectance correction for the sake of time and because the refractive index of each sample is needed to accurately correct the spectrum.

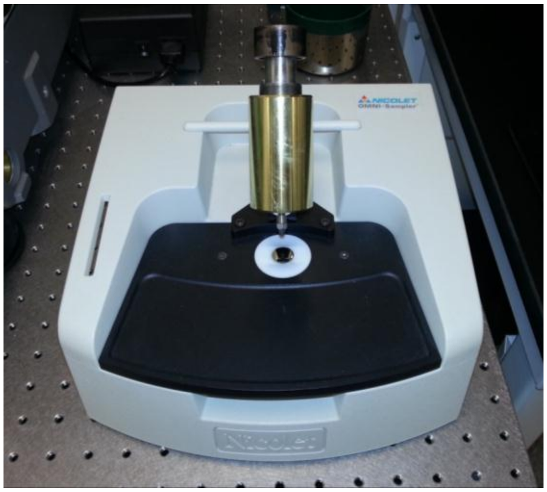


Figure 3.1 Thermo Omni Sampler Single Bounce ATR with germanium window

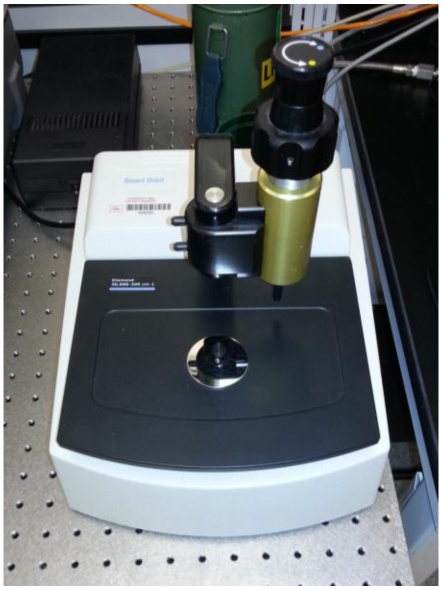


Figure 3.2 Thermo Smart Orbit Single Bounce ATR with diamond window

The difference between the two ATR accessories was the depth of penetration which is based on the refractive index of the substrate crystal. The germanium crystal having a refractive index of 4.0 in the infrared region has a much shallower depth of penetration into the clear coat sample and therefore a much weaker spectrum. The diamond crystal with a refractive index of 2.6 produced a spectrum with a higher absorbance range and better signal-to-noise. The final method that was evaluated utilized a FT-IR microscope outfitted with a 15 X gold-coated Cassegrain lens along with a diamond anvil cell (Figure 3.4). For each sample having a visible clear coat the sample was first gently scraped with a micro knife to remove any debris or coatings. Then a small sample was excised and transferred to the diamond anvil cell. The sample was compressed in the diamond anvil cell, allowed a moment to rest or anneal, and then the top window was removed. The sample was evaluated under a stereoscope prior to sample analysis. If the sample was not flat against the lower window, it was compressed again until no air gap was present between the sample and the diamond substrate. This was done to prevent constructive/destructive interference caused by reflection between the sample and the diamond substrate.

For each spectrum, 128 scans taken at $4cm^{-1}$ resolution were averaged to produce the final spectrum. Box car apodization was used in the event that further processing would require a change to apodization function. In all three methods, five individual preparations of each sample were made and analyzed.

3.2 Fourier Transform Infrared Results

All the commercial waxes analyzed, even those labeled as carnauba wax, where shown to be primarily silicone oil or gel. Figure 3.1 shows a comparison between a spectrum from the Aldrich FT-IR library of carnauba wax against that of the commercial brands. None of the clear coat samples analyzed showed a visual indication of the silicone compounds.

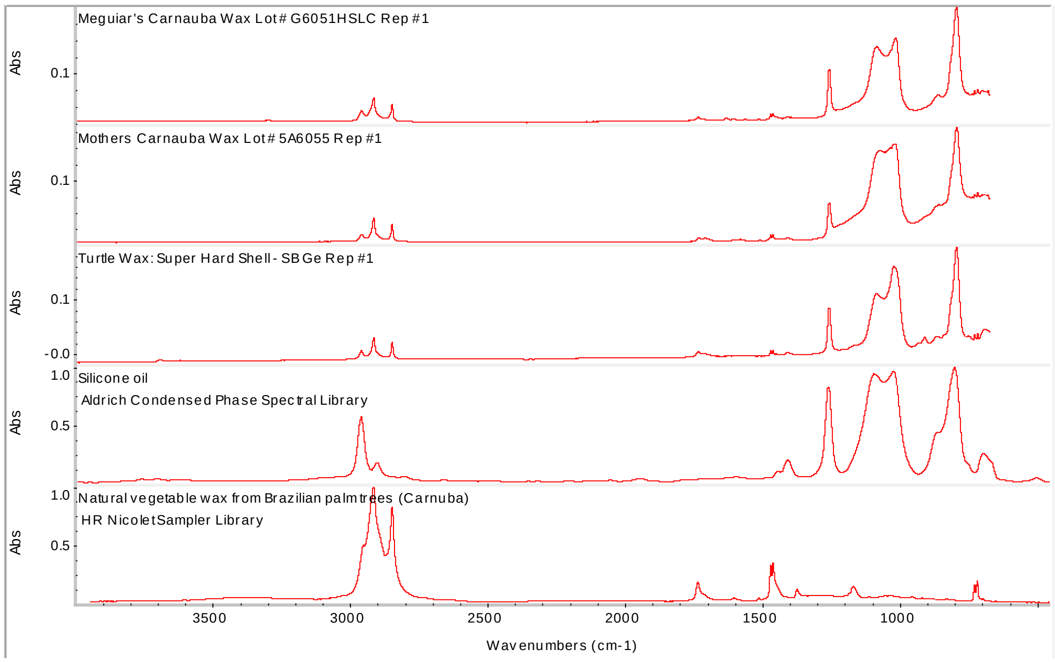


Figure 3.3 FT-IR spectra of different waxes/polishes shown with reference spectra

3.3 Final method

Several samples were analyzed by each method and compared visually. Visual comparison of the spectral data from the three methods indicated that the automatic correction for the ATR methods was overcompensating in the 2000-700 cm^{-1} region and fine detail of the spectral data was being lost (Figure 3.5). The single bounce accessories are also not as common in forensic laboratories while the FT-IR microscope is the primary instrument for spectral analysis of trace samples. Because of this the FT-IR microscope technique was selected as the final method.

Figure 3.4 Thermo Scientific Continuμm FT-IR Microscope

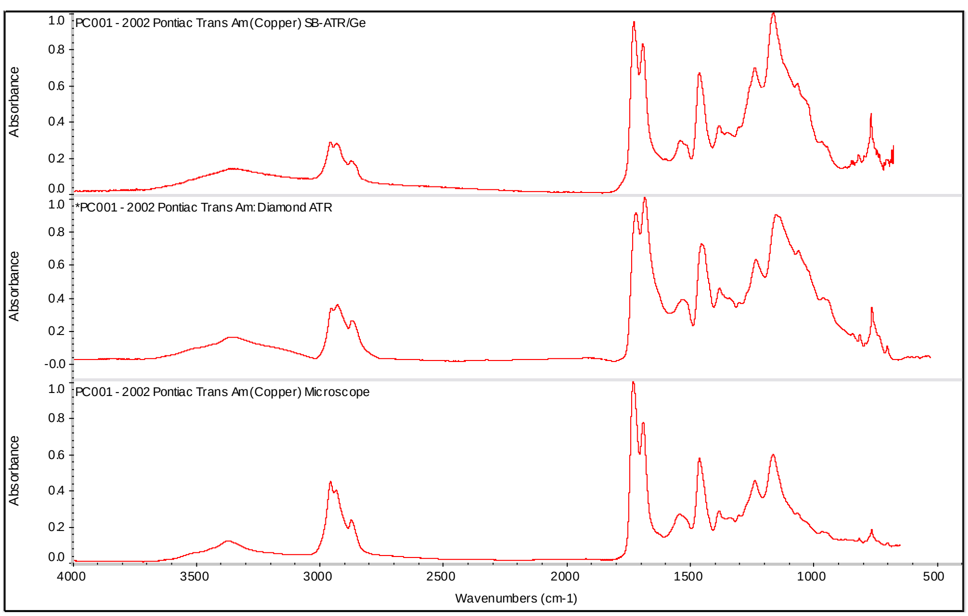


Figure 3.5 FT-IR spectra of one sample analyzed by three different techniques

Spectral data was saved as groups containing all five replicates of an individual sample. Once all samples were analyzed the spectra groups were processed prior to statistical analysis. This preprocessing involved baseline correction and normalization. The files were then converted from the Thermo scientific proprietary format to a comma separated variable format and transferred to an Excel spreadsheet. To ensure consistency in data handling, a series of macro programs were created to accomplish the preprocessing and data conversion (Appendix B). The CSV files for the five spectra of each paint chip were transferred to individual Microsoft Excel worksheets. All 180 worksheets were combined into one Microsoft Excel workbook along with data sheets of summary data. The summary data was made up of spectra generated from the average of the five individual spectra. It was this data sheet of the averaged spectra that was transferred to statistical modeling software, JMP. All statistical modeling was done using version 8.0 of the JMP software.

FT-IR spectra of the different clear coats were collected over several months. The 200 samples analyzed generated 180 sample sets. Each sample set contained five unique spectra. Raw data can be found in Appendix A. Numerous paint chip samples did not exhibit a clear coat layer. Although not relevant to this study, the absence of a clear coat is in of itself a factor that can be used to identify the type of vehicle in the case.

3.4 Agglomerative Cluster Analysis

AHC was used to evaluate the data set twice. The first time was using the full spectral data set of 625 to 4000 cm^{-1}. Following examination using PCA and factor loading analysis it was found that the stretching region was adding little in the way of discernment and a smaller data set consisting of just the finger print regions was evaluated for the second evaluation (Figure 3.6). Numerous differences were apparent between the two graphs. The distances between samples changed severely in some cases moving samples to different groups. When reviewing the actual spectra of the groups smaller but meaningful bands in the fingerprint region of the infrared were ignored when the stronger bands in the functional group region were included.

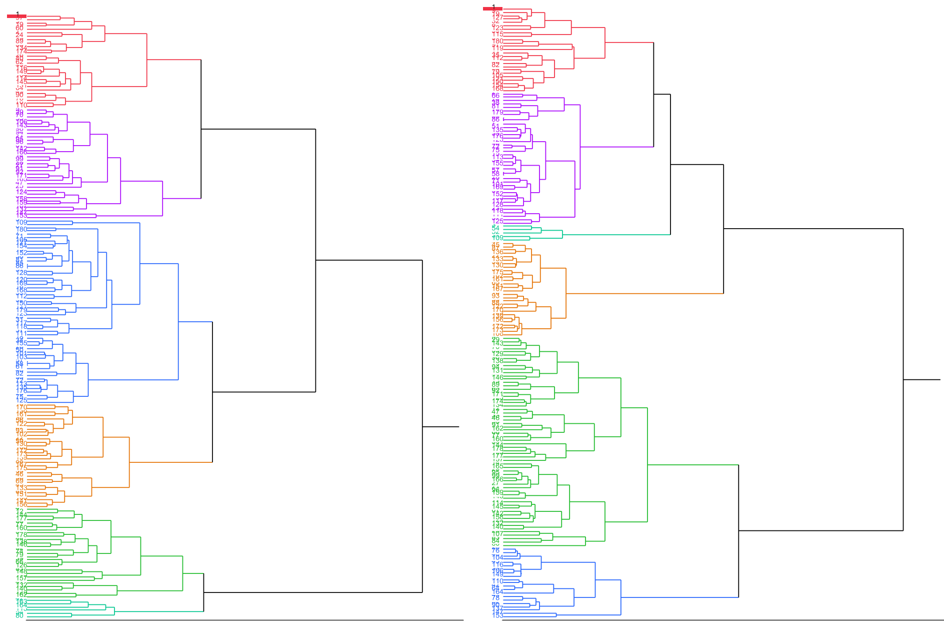


Figure 3.6 Dendrograms generated from full spectrum data (left) and fingerprint region (right) The color scheme is based on six groups

Review of the actual spectra indicated that the dendrogram of just the fingerprint region correlated with a visual sorting of the spectra. Example spectra of the different classes from the fingerprint dendrogram are shown in Figure 3.7. The groups designated as red and blue from the fingerprint dendrogram in Figure 3.6 were combined into Class 1 in Figure 3.7 based on similarities in spectral features.

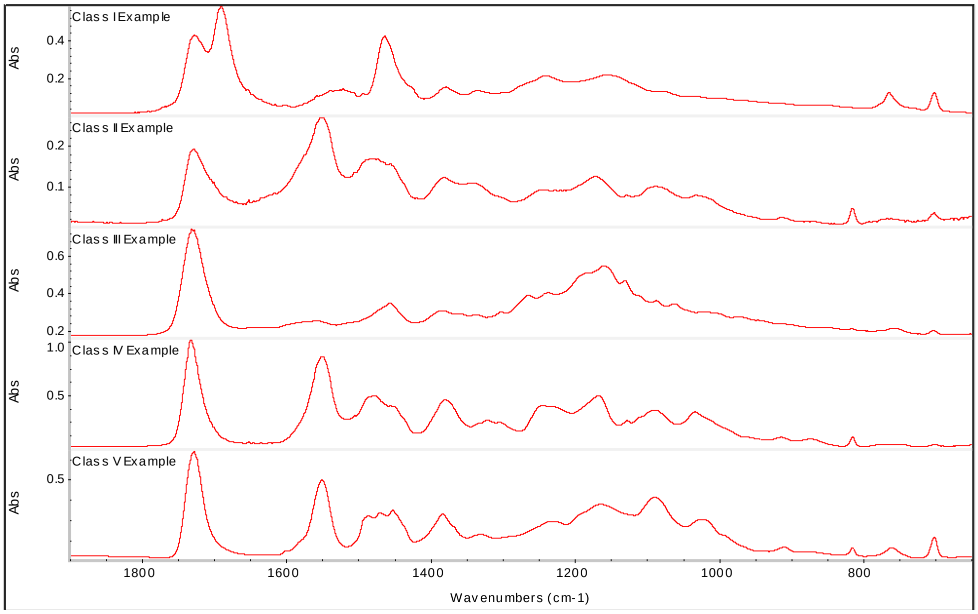
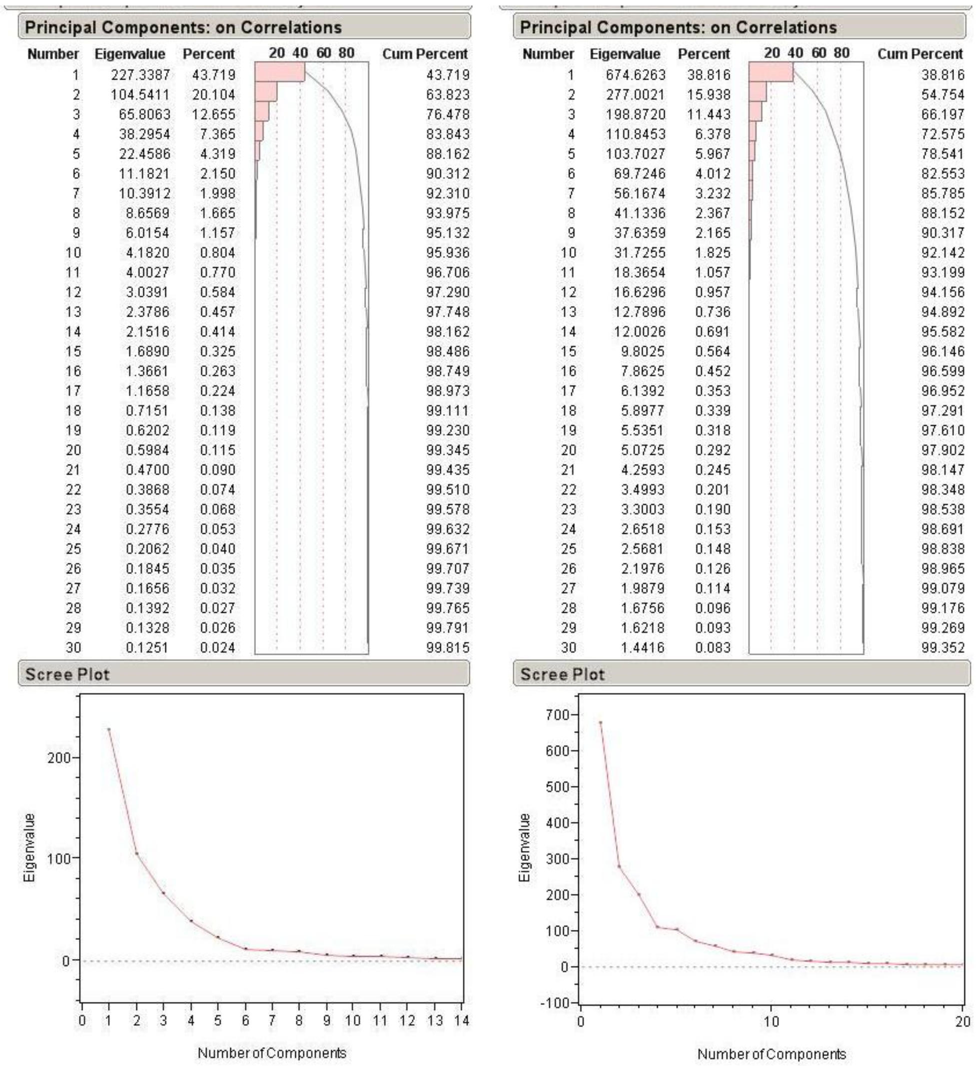


Figure 3.7 Examples of the different groups based on fingerprint region

3.5 Principal Component Analysis

The same data set was used for PCA. Although thirty principal components were calculated by the software, only a certain number are relevant. The relevant ones can be determined by three methods. The first is visually using the scree plot. The scree plots in Figure 3.8 show a visible slope change which would indicate six principal components for the plot from the fingerprint region (left) and no real definitive break in slope for the full spectrum data set (right). A second method, the Kaiser Criteria, which is those principal components that have an eigenvalue greater than one, would indicate seventeen components for the fingerprint region scree plot (left) or more than thirty for the full spectrum plot (right).[10] The third method is to use a set cumulative variance such as 95% or 99% and using the number of principal components that meet or exceed that criterion. Using the 95% cumulative variance method would indicate nine principal components for the fingerprint region and fourteen for the full spectrum data set. The Kaiser Criteria produced too many principal components and was not used.



Principal Components: on Correlations

Number	Eigenvalue	Percent	Cum Percent
1	227.3387	43.719	43.719
2	104.5411	20.104	63.823
3	65.8063	12.655	76.478
4	38.2954	7.365	83.843
5	22.4586	4.319	88.162
6	11.1821	2.150	90.312
7	10.3912	1.998	92.310
8	8.6569	1.665	93.975
9	6.0154	1.157	95.132
10	4.1820	0.804	95.936
11	4.0027	0.770	96.706
12	3.0391	0.584	97.290
13	2.3786	0.457	97.748
14	2.1516	0.414	98.162
15	1.6890	0.325	98.486
16	1.3661	0.263	98.749
17	1.1658	0.224	98.973
18	0.7151	0.138	99.111
19	0.6202	0.119	99.230
20	0.5984	0.115	99.345
21	0.4700	0.090	99.435
22	0.3868	0.074	99.510
23	0.3554	0.068	99.578
24	0.2776	0.053	99.632
25	0.2062	0.040	99.671
26	0.1845	0.035	99.707
27	0.1656	0.032	99.739
28	0.1392	0.027	99.765
29	0.1328	0.026	99.791
30	0.1251	0.024	99.815

Principal Components: on Correlations

Number	Eigenvalue	Percent	Cum Percent
1	674.6263	38.816	38.816
2	277.0021	15.938	54.754
3	198.8720	11.443	66.197
4	110.8453	6.378	72.575
5	103.7027	5.967	78.541
6	69.7246	4.012	82.553
7	56.1674	3.232	85.785
8	41.1336	2.367	88.152
9	37.6359	2.165	90.317
10	31.7255	1.825	92.142
11	18.3654	1.057	93.199
12	16.6296	0.957	94.156
13	12.7896	0.736	94.892
14	12.0026	0.691	95.582
15	9.8025	0.564	96.146
16	7.8625	0.452	96.599
17	6.1392	0.353	96.952
18	5.8977	0.339	97.291
19	5.5351	0.318	97.610
20	5.0725	0.292	97.902
21	4.2593	0.245	98.147
22	3.4993	0.201	98.348
23	3.3003	0.190	98.538
24	2.6518	0.153	98.691
25	2.5681	0.148	98.838
26	2.1976	0.126	98.965
27	1.9879	0.114	99.079
28	1.6756	0.096	99.176
29	1.6218	0.093	99.269
30	1.4416	0.083	99.352

Figure 3.8 Scree plot for full spectrum data (right) verses fingerprint region (left)

Because there is such a difference between data sets a plot of the factor loading values was plotted verses the spectral range to visualize the most useful regions of the infrared spectrum. A factor loadings plot represents the cosine of the angle between a principal component and another variable, in this case the wavenumber. A positive correlation between two variables exists if the cosign of the angle is positive and a negative correlation exists if the cosine of the angle is negative. There is no correlation if the cosine of the angle is zero.[24] This plot indicated that the functional group region

(2000 - 2700 cm^{-1}) was less useful with regard to discriminating between groups (Figure 3.9). Although some structure is seen in the factor loading plot in the region of 2700 to 3700cm^{-1}, PCA and AHC workups of that region did not indicate any predictive ability. Following this analysis, the AHC and PCA analysis was repeated using only the region from 950cm^{-1} to 1950cm^{-1}. The time needed to calculate results was strikingly reduced as a result of the smaller data matrix.

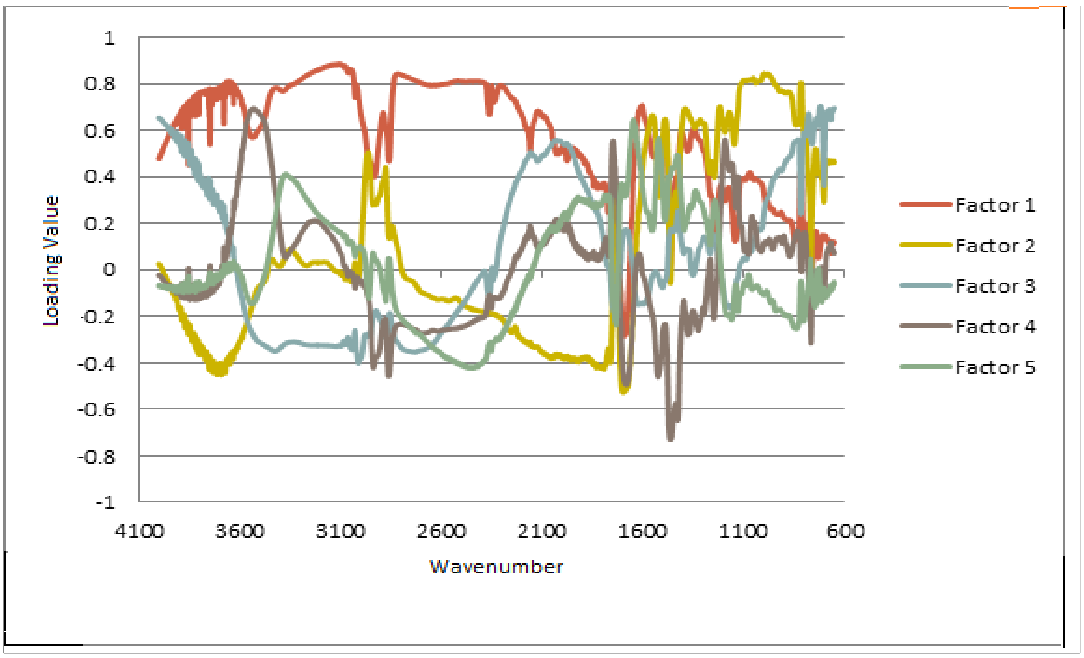


Figure 3.9 Factor loading plot of first five principal components versus wavenumber

Using the smaller data set the color coding from the HCA was superimposed onto the three dimensional model of the first three principal components. Although there is overlap between groups, there is also a definite pattern to the data set (Figure3.10).

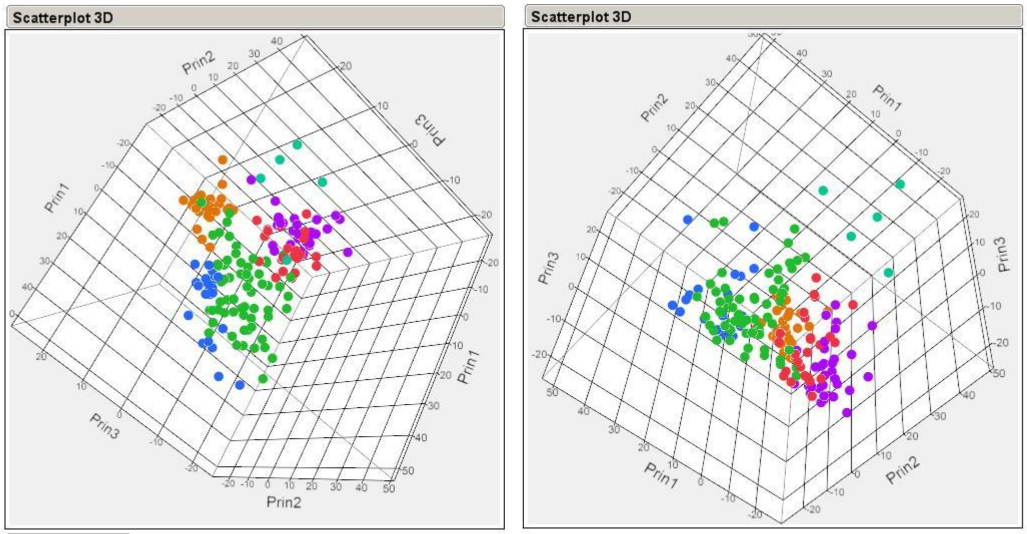


Figure 3.10 Two different views of the first three principal components plotted in 3D

3.6 Discriminant Analysis

Using the principal components calculated from the spectral range 950 cm^{-1} to 1950 cm^{-1} a series of linear discriminate analyses were calculated using both the first six and the first nine principal components. Three different categories were used as the x-values; cluster group, year, and make. The six canonical plots are shown in Figures 3.11 through 3.14. No predictive value is seen with the plots using make or year, but discriminate analysis using the cluster groups from the AHC do show the ability to predict clear coat based on chemical class. The canonical plot from the DA using nine PC has approximately half the error of the DA using six PC. In the cluster group constrained DA using six principal components, seventeen samples were mischaracterized when evaluated using the leave one out method. The nine principal components DA only miss characterized eight samples. In each of the plots a -2loglikelihood result is shown. This result is an evaluation of the fit of the model. Smaller likelihoods of misclassification relate to better fits.[23]

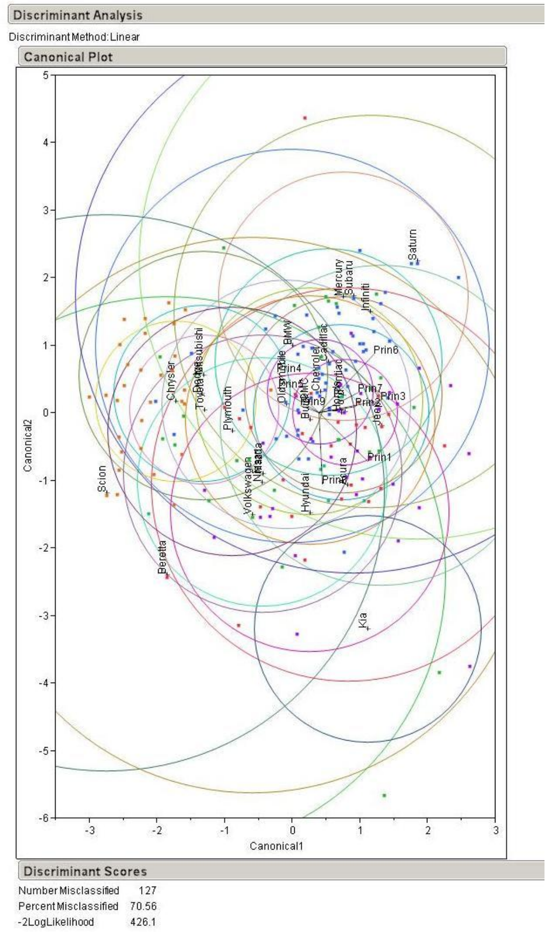


Figure 3.11 DA Canonical plot of principal components versus make

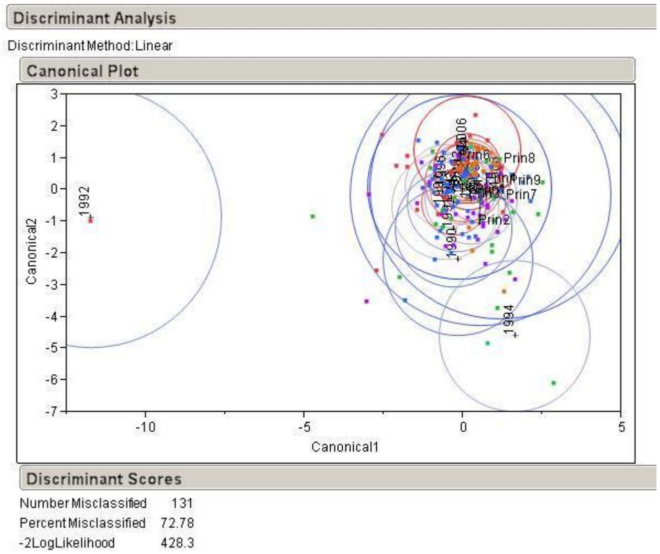


Figure 3.12 DA Canonical plot of principal components versus year

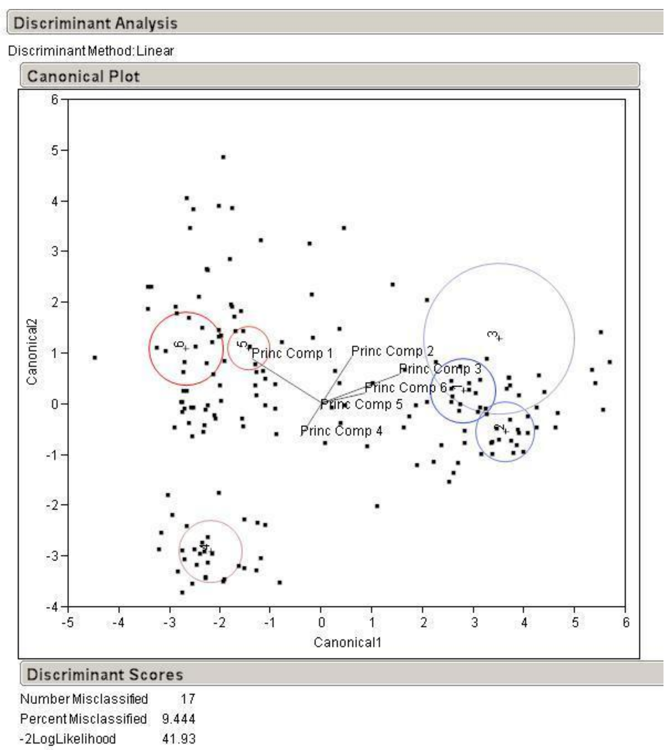


Figure 3.13 DA Canonical plot of principal components versus AHC cluster group using first 6 PCs

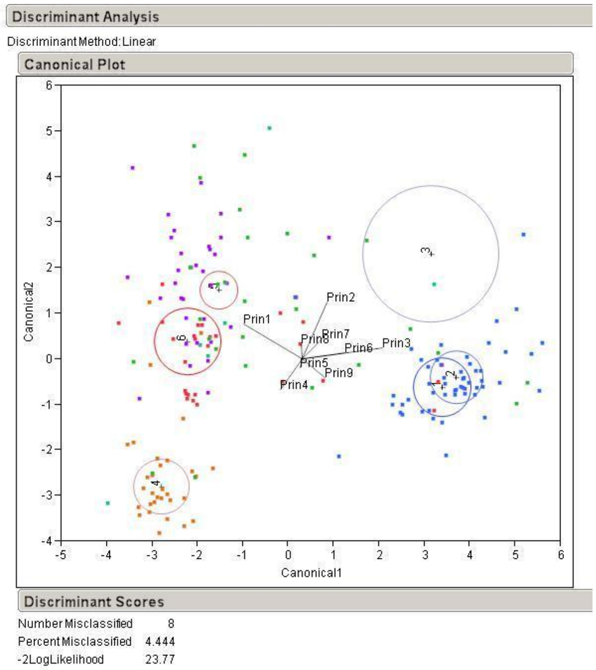
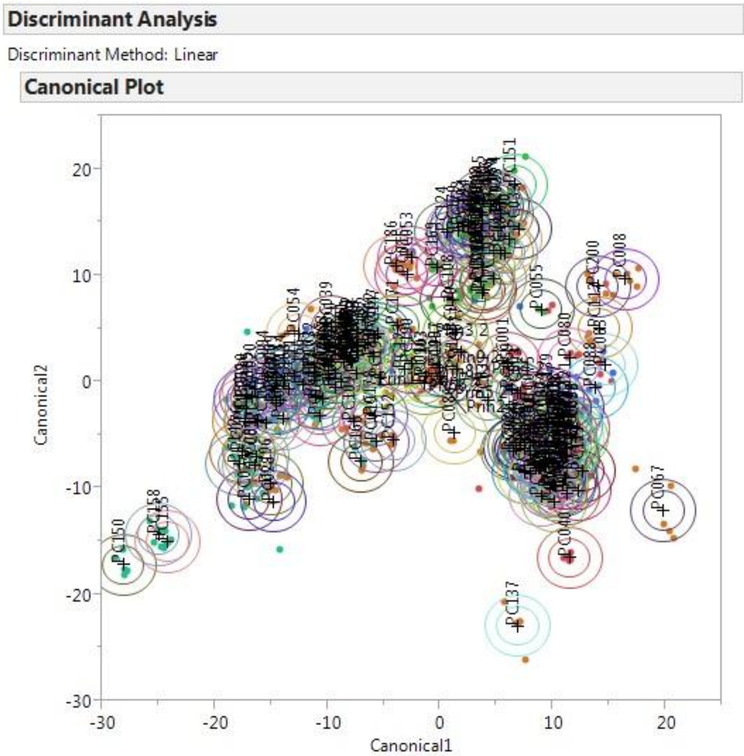


Figure 3.14 DA Canonical plot of principal components versus AHC cluster group using first 9 PCs

Finally a set of plots were determined using the same spectral range, but using all five original spectra rather than the average. Cluster analysis and a new set of principal components were calculated. Results were comparable to the averaged sample data. For the discriminant analysis the sample number was used for the x-axis making each sample its own class. The canonical plot of that discriminate analysis using the first nine principal components is shown in Figure 3.15.



Score Summaries

	Training
Number Misclassified	111
Percent Misclassified	12.33
-2LogLikelihood	967.9

Figure 3.15 Canonical plot of principal components versus sample number

The percent misidentified is low indicating that the chemometric analysis can identify the material with some degree of accuracy if a sample has been included into the set. This is similar to spectral library searching, but using discriminant analysis. Note that the -2loglikelihood of misclassification is relatively high indicating a possibly poor fit for the model.[24]

CHAPTER 4. FUTURE WORK

There were notable limitations with this study that if corrected might improve the predictive ability of the statistical model such that it might be able to discern make, model, or year. These limitations all were related to lack of information regarding the samples. Although color, year, make, and model were captured for the vehicles, the Vehicle Identification Number (VIN) and color coding information were not.
Every vehicle manufactured is issued an identification number that acts as both a unique identifier and a description of the vehicle. From the VIN the vehicle's history can often be obtained providing even more relevant information. Figure 4.1 shows how a VIN is broken down. [24]

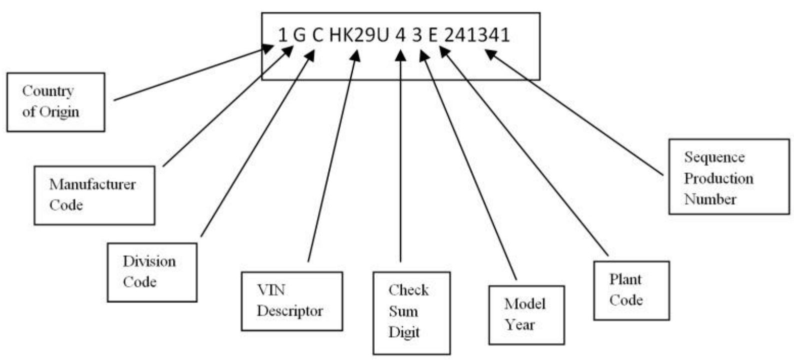


Figure 4.1 Vehicle Identification Number Breakdown

Each manufacturer decides the code structure for their manufacturing lines so long as it fits the prescribed format. The first numbers detail the country of origin, the manufacturer, and division. The next set is the manufacture's coding for describing the features or options package. The ninth digit is a check sum value used to verify the accuracy and authenticity of the VIN. The final numbers identify the model year, the plant code and finally the sequence production number for that manufacturer. [25] The number in Figure 4.1 describes a United States General Motors Chevy Silverado 4X4 with a 6L engine manufactured in 2003 at the Flint Michigan plant and was the 241341st unit made that year.

The paint color information is found on the inside of the glove compartment or on the inside of the driver's side door. This information relates to the color of paint used on the vehicle it need to be repaired. In recent years the VIN is included on this sticker for easier access.

Together these two pieces of information can be used to determine where the car was manufactured and if the current color matches the factory paint. The VIN can also be used to search for information related to accidents the car may have been involved. This is another method for determining if the color and the finish are factory original. This is important as there is no way to properly identify the reason that several vehicles from the same year have markedly different clear coats. Figure 4.2 displays the FT-IR spectra from the clear coats of three different 1998 Chevy Blazers.

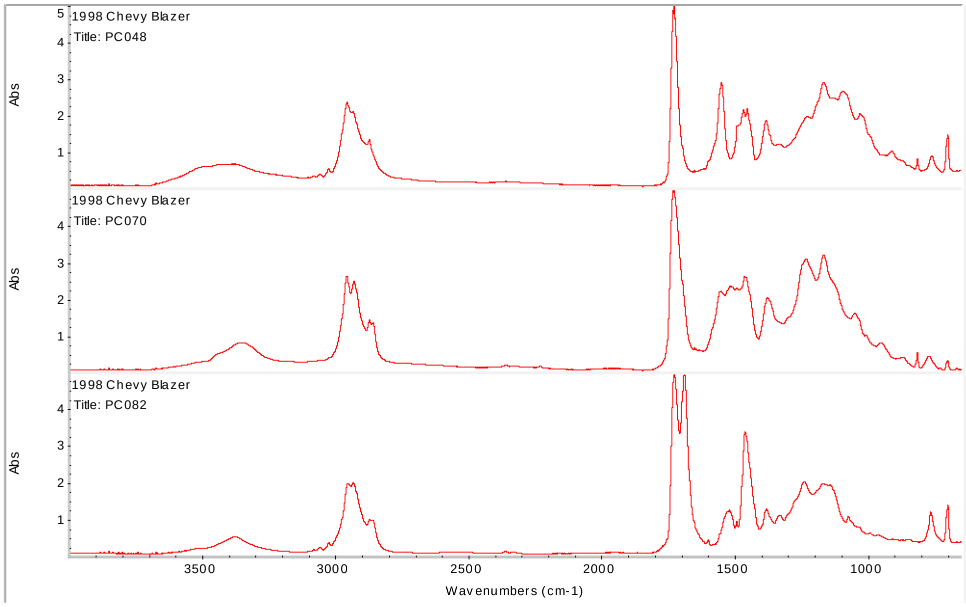


Figure 4.2 Spectra of different 1998 Chevy Blazers with distinctly different clear coat spectra

There are significant differences between these three samples and without the VIN or some vehicle history there is no way to discern if these differences are associated with repairs, manufacturing site or miss labeling during sample collection. The Chevy Blazer and GMC Jimmy were both produced at the same three production sites. [26, 27] Locating information regarding these manufacturing sites may prove difficult as all three have been shuttered by General Motors.

The same may be true for the Honda Civic which is manufactured at three sites in North America (Figure 4.3).[28]

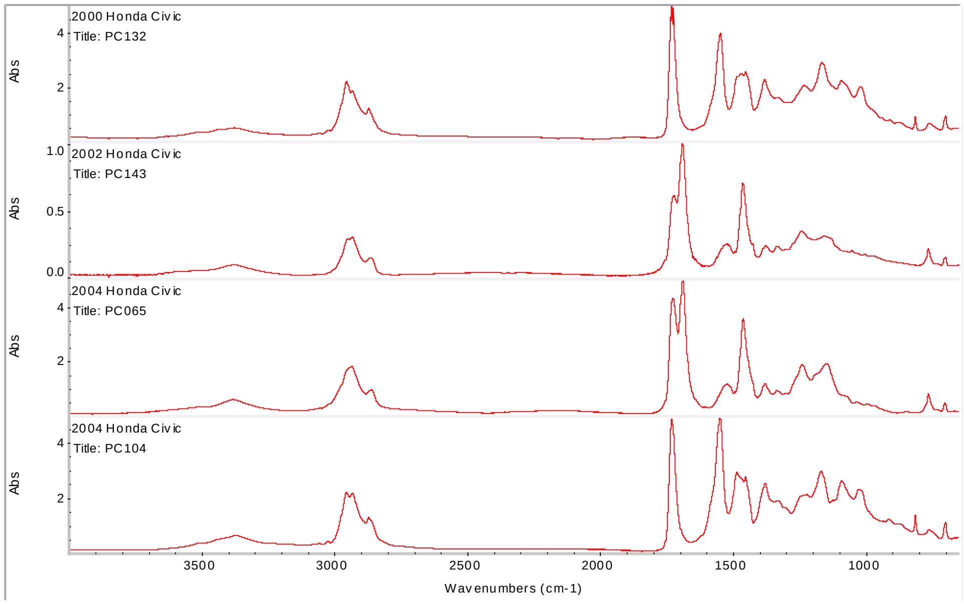


Figure 4.3 Spectra of different Honda Civics with distinctly different clear coat spectra

There are three different spectra over a four year period with no way to determine if the manufacturer changed clear coat formulation, if each plant site used a different clear coat during that period, or if one or more vehicles has had paint and or body work done at some time prior to sample collection.

Going forward it may be prudent to acquire exemplars from the different manufacturers so that samples taken in the field can be compared to them to determine if the paint is still OEM.

Advances in instrumentation may make additional work in this area much easier. Hand held units for Raman and FT-IR analysis are now available from several companies and are being used in the field by federal law enforcement.[29] Vehicles in junk yards or those brought into impound lots could be scanned at multiple locations and all prevalent data such as color and VIN can be entered into the same data files. Hand held units are then synced with a main computer where they can be processed.

The percent misclassified result seen in the canonical plots from the discriminant analysis should not be construed as an error rate. The percent misclassified is based only on this data set and does not include any samples external to the matrix used to generate it. To satisfy the Daulbert standard, a true error rate determination would require samples of known origin and composition to be tested against a matrix of control samples. The learning matrix would have to be expanded as new clear coat formulations came onto the market.

CHAPTER 5. CONCLUSION

This body of work demonstrated several facts. The first is the power of chemometric analysis for forensic and chemical study, a fact that has been shown repeatedly over time. Second was the ability of FT-IR to analyze and differentiate between different types of automotive clear coats. Finally it demonstrated the necessity of planning out a study in detail to ensure that it has all the information needed to accomplish its goals.

FT-IR microscopic analysis is common in most forensic laboratories and the skill set needed to accomplish the type of work done in this study is already present. The only issue is the cost of the diamond anvil, or diamond compression cell needed to complete the preparation of the samples. This expensive accessory may be beyond the budget of some laboratories.

The chemometric analysis of the FT-IR data using AHC, PCA, and DA indicate that the chemical classification of the automotive clear coat can be determined with some accuracy. The region of the mid-infrared that was found to be the most discriminating was the region of 1950 cm^{-1} to 950 cm^{-1}. Future work in this area will need to involve building a data set that has more background on the individual samples along with exemplars to establish if the sample is OEM or aftermarket clear coat. With this type of data set the capability to determine year, manufacturer, or model using chemometric analysis can be established.

LIST OF REFERENCES

LIST OF REFERENCES

1. Liszewski, E.A., et al. Characterization of Automotive Paint Clear Coats by Ultraviolet Absorption Microspectroscopy with Subsequent Chemometric Analysis. *Applied Spectroscopy* **2010**, *64* (10), 1122-1125.
2. Geladi, P., et al. Chemometrics in Spectroscopy; Part 2. Examples. *Spectrochimica Acta Part B* **2004**, *59* 1347-1357.
3. Mendlein, A.N. *Instrumental and Chemometric Analysis of Automotive Clear Coat Paints by Micro Laser Raman and UV Microspectroscopies*. Purdue University: Lafayette, IN, 2011.
4. Goodpaster, J.V., et al. Identification and Comparison of Electrical Tapes Using Instrumental and Statistical Techniques: 1. Microscopic Surface Texture and Elemental Composition. *Journal of Forensic Sciences* **2007**, *52* (3), 610-629
5. Morgan, S.L., and Bartick, E.G.Discrimination of Forensic Analytical Chemical Data Using Multivariate Statistics. In: Blackledge, R.D., ed. *Forensic Analysis on the Cutting Edge: New Methods for Trace Analysis*. John Wiley & Sons, Inc.: New York, 2007.
6. National Research Council. *Strengthening Forensic Science in the United States: a path forward*. National Academies Press: Washington, D.C., 2009.
7. Daubert v. Merrell Dow Pharmaceuticals, Inc., 509 US 579, 589 (1993).
8. Beebe, K.R., et al. *Chemometrics: A Practical Guide*. John Wiley & Sons, Inc.: New York, 1998.
9. Kramer, R. *Chemometric Techniques for Quantitative Analysis*. Marcel Dekker, Inc.: New York, 1998.

10. Brereton, R.G. *Chemometrics: Data Analysis for the Laboratory and Chemical Plant*. John Wiley & Sons, Inc.: Chichester, England, 2003.

11. Johnson, R., and Wichern, D. *Applied Multivariate Statistical Analysis*. Prentice Hall: Englewood Cliffs, NJ, 1982.

12. Everitt, B. *Cluster Analysis*. Heinemann Educational Books Ltd: London, 1974.

13. Johnson, D.E. *Applied Multivariate Methods for Data Analysts*. Duxbury Press: New York, 1998.

14. Colthup, N.B., Daly, N.H., and Wiberley, S.E. *Introduction to Infrared and Raman Spectroscopy, 3rd ed*. Academic Press, Inc.: New York, 1990.

15. Smith, B.C. *Fundamentals of Fourier Transform Infrared Spectroscopy*. CRC Press: New York, 1996.

16. Ferraro, J.R. and Dasile, L.J. *Fouier Transform Infrared Spectroscopy: Applications to Chemical Systems, Vol. 1*. Academic Press: New York, 1978.

17. Colemam, P.B., *Practical Sampling Techniques for Infrared Analysis*. CRC Press: New York, 1993.

18. ThermoFisher Scientific, Scientific Spectroscopy Seminar Series: *Advances in FT-IR Microscopy,* (presentation at Airport Holiday Inn, Indianapolis, IN, April, 2010).

19. United States Department of Transportation, *2011Motor Vehicle Crashes: Overview, Traffic Safety Facts*, Research note, DOT HS 911 701, December 2012.

20. Indiana Criminal Justice Institute and Center for Criminal Justice Research. *Indiana Crash Facts 2012*. Miller, S., Ed., Indiana University: Indianapolis, IN, 2012, 28.

21. Domnick, J., et al. Investigations of the Drying Process of a Water Based Paint Film for Automotive Applications. *Chemical Engineering and Processing*, 2011, (50), 495-502.

22. Streitberger, H. and Dössel, K. *Automotive Paints and Coatings, Second Ed.*, Wiley-VCH: Weinheim, Germany, 2008.

23. Overbeck, A. Polymer Heterogenicity in Waterborne Coatings. *Journal of Coating Technology and Research*. 2010, 7 (1), 1-21.

24. StatSoft, Inc. Principal Components and Factor Analysis. In: *Electronic Statistics Textbook.* StatSoft: Tulsa, OK, 2011. Accessed March 14, 2014. WEB: http://www.statsoft.com/textbook/.
25. VIN Number Decoder. Insider Car Buying Tips. Accessed April 2, 2014. WEB: http://www.insider-car-buying-tips.com/vin_number_decoder.html#5.
26. GM Salaried Retirees, Detroit Assembly. In: GM Plant History. Accessed April 2, 2014. Accessed April 2, 2014. WEB: http://www.gmsalariedretirees.com/GMplantHistory.html.
27. Peterson, S. Chevy's history runs deep at Moraine Assembly Plant. Springfield News-Sun. 2011. Accessed April 2, 2014. WEB: http://www.springfieldnewssun.com/news/classifieds/cars/chevys-history-runs-deep-at-moraine-assembly-pla-1/nMxTp/.
28. Honda Manufacturing Facilities in North America – Fact Sheet. New and Views. 2007. Accessed April 3, 2014. WEB: http://www.honda.com/newsandviews/article.aspx?id=200704023919.
29. Eckenrode, B.A., et al. U.S. Federal Bureau of Investigation. Portable Raman Spectroscopy Systems for Field Analysis. Washington: FSC, 2001.

APPENDICES

Appendix A Clear Coat Spectra by FT-IR Spectroscopy

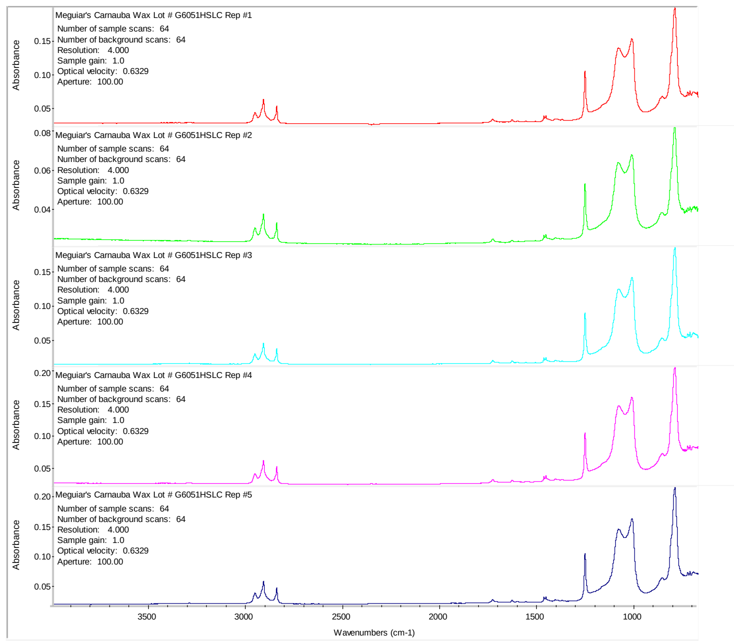
Title: Meguiar's Carnauba Wax Lot # G6051HSLC

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with germanium window.



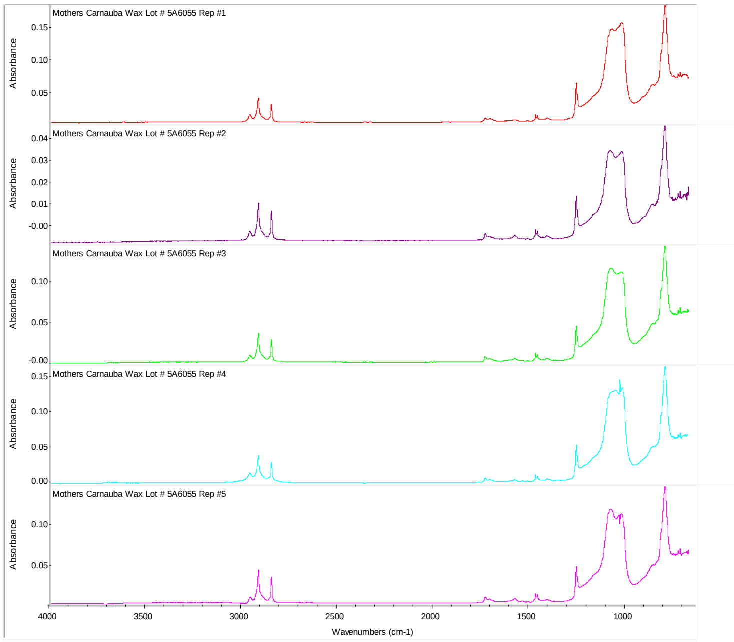
Title: Mothers Carnauba Wax Lot # 5A6055

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with germanium window



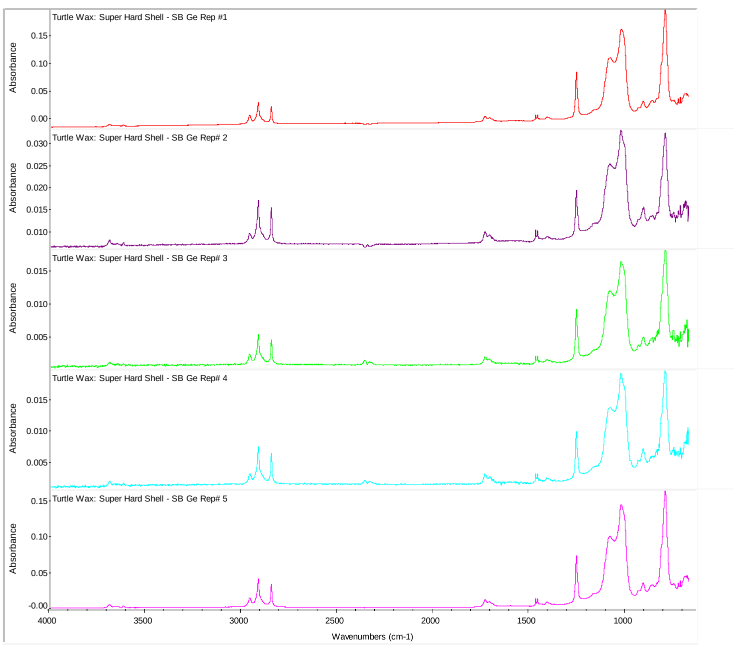
Title: Turtle Wax: Super Hard Shell

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with Ge crystal.



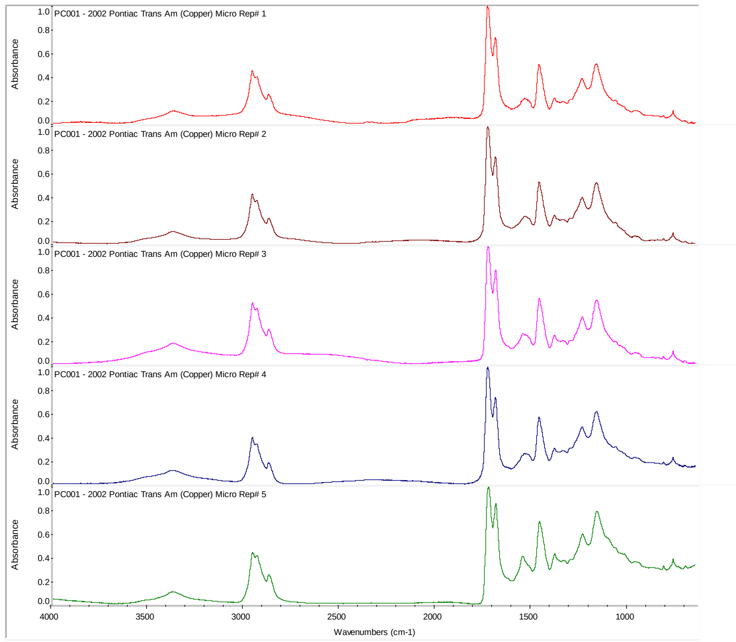
Title: PC001 - 2002 Pontiac Trans Am (Copper)

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Microscope with diamond anvil cell.



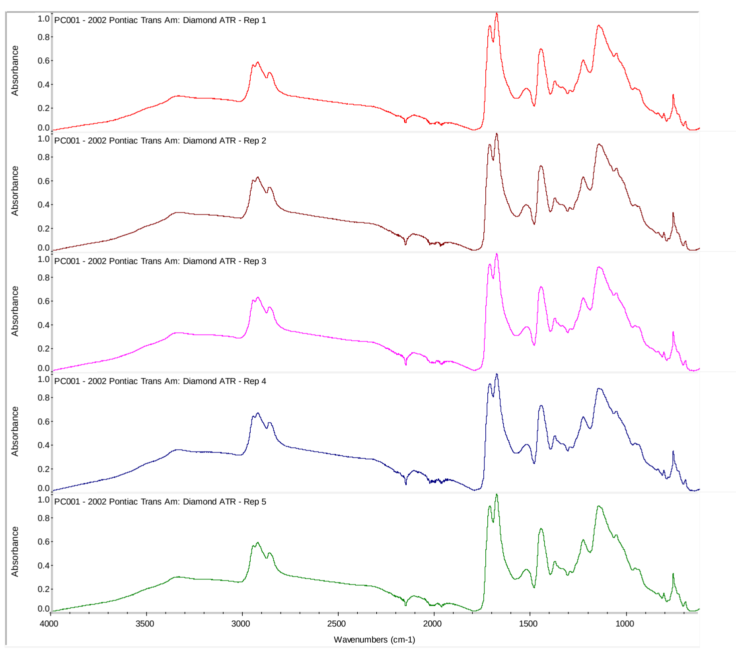
Title: PC001 - 2002 Pontiac Trans Am

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with diamond w



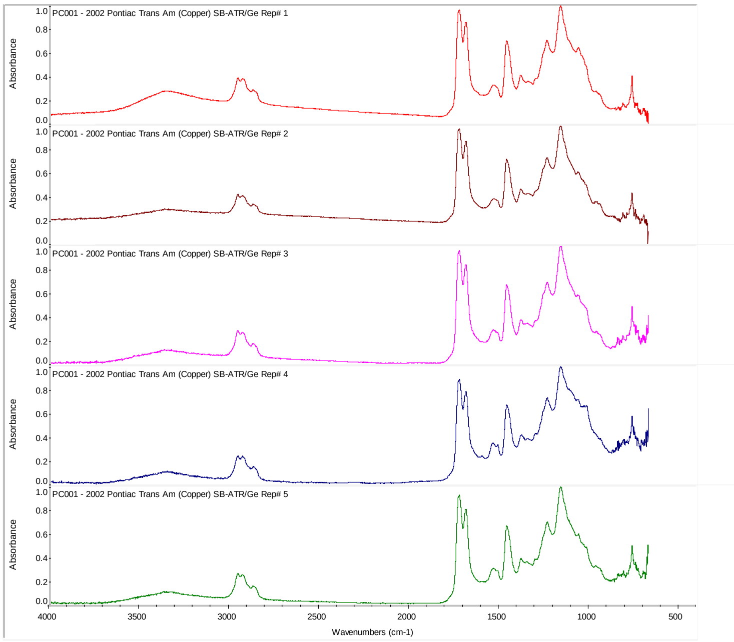
Title: PC001 - 2002 Pontiac Trans Am (Copper)

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with germanium



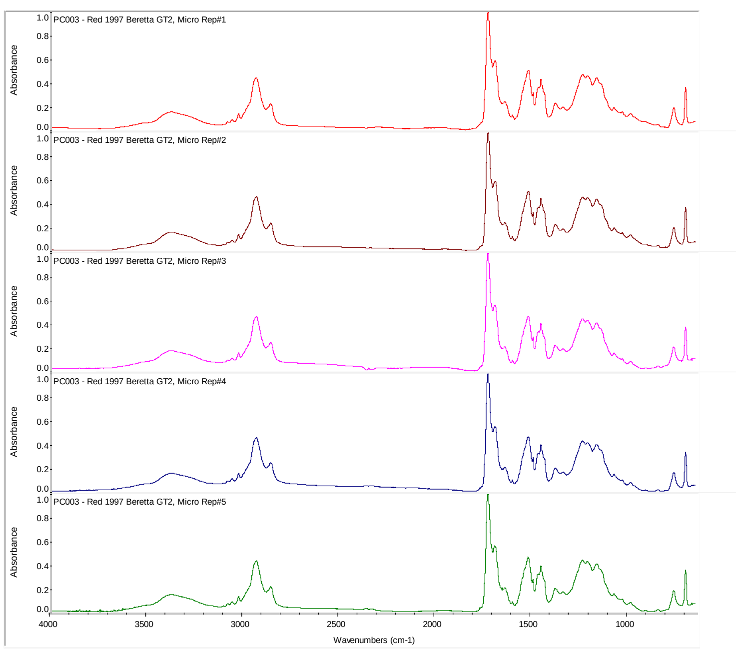
Title: PC003 - Red 1997 Beretta GT2

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Microscope with diamond anvil cell.



Title: PC003 - Red 1997 Beretta GT2

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR
with diamond window.

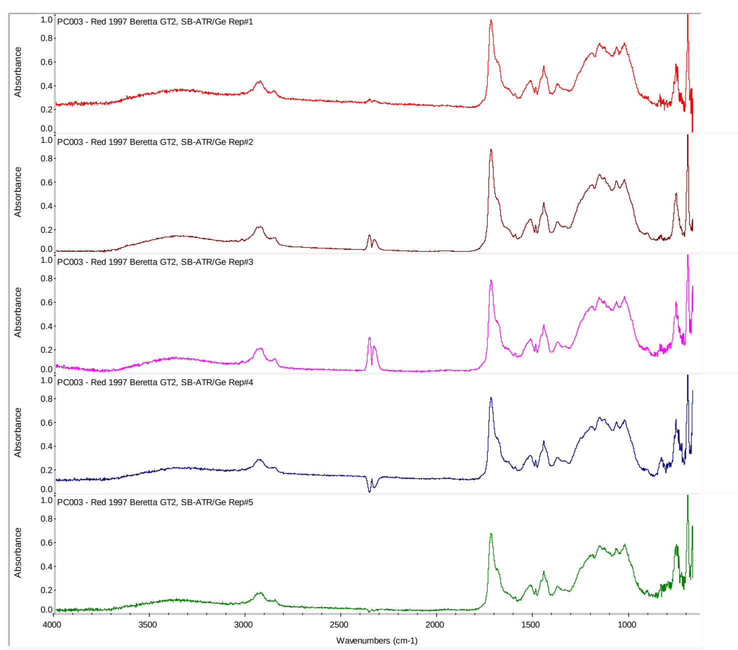
Title: PC003 - Red 1997 Beretta GT2

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR
with germanium window.



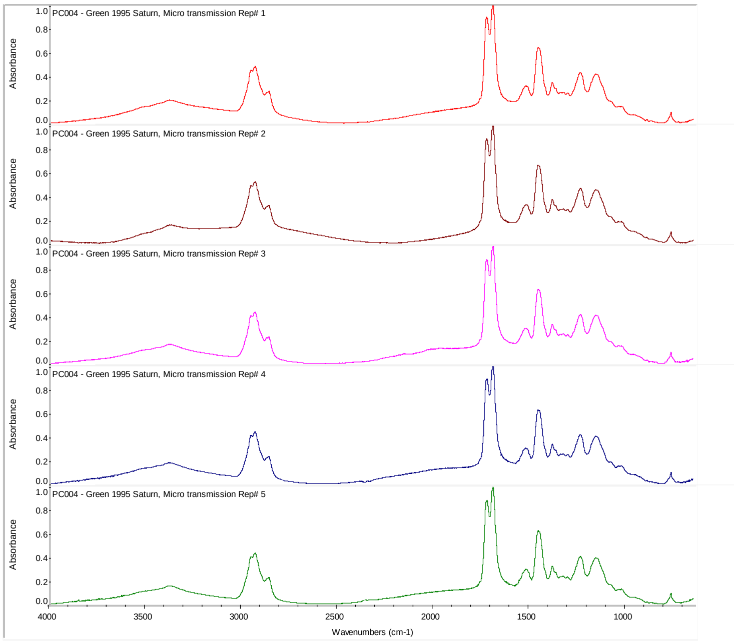
Title: PC004 - Green 1995 Saturn

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Microscope with diamond anvil cell (2 windows)



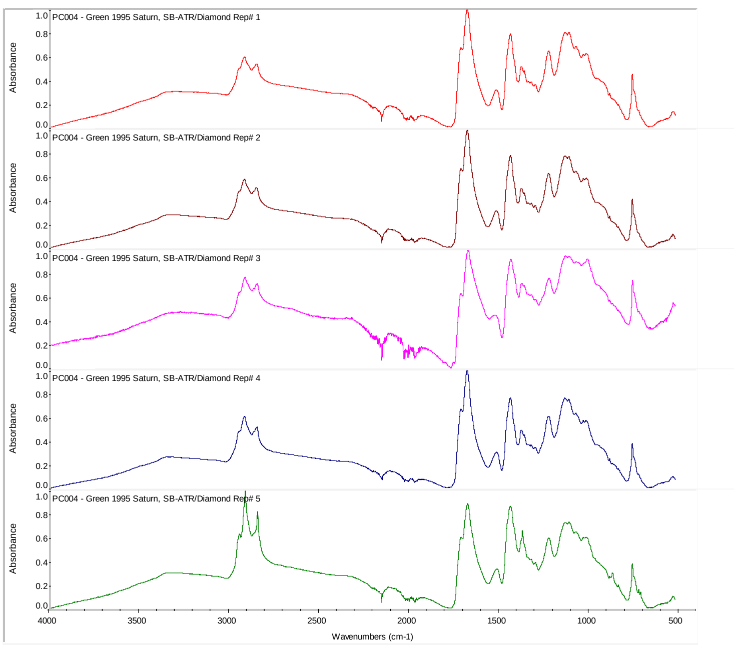
Title: PC004 - Green 1995 Saturn

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with diamond window.



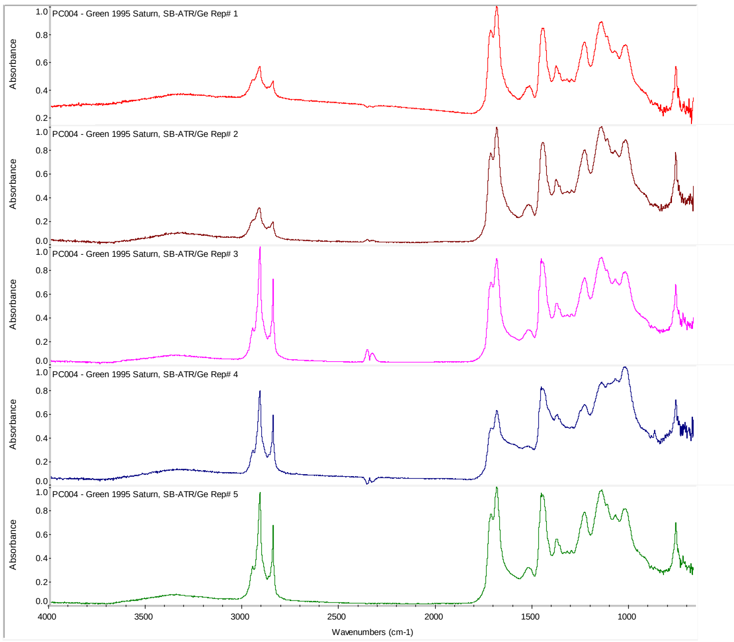
Title: PC004 - Green 1995 Saturn

Analyst: James D. Osborne

Number of sample scans: 64
Number of background scans: 64
Resolution: 4.000
Sample gain: 1.0
Optical velocity: 0.6329
Aperture: 100.00

Detector: DTGS KBr
Beamsplitter: KBr
Source: IR

Comment:
Single bounce ATR with germanium window.



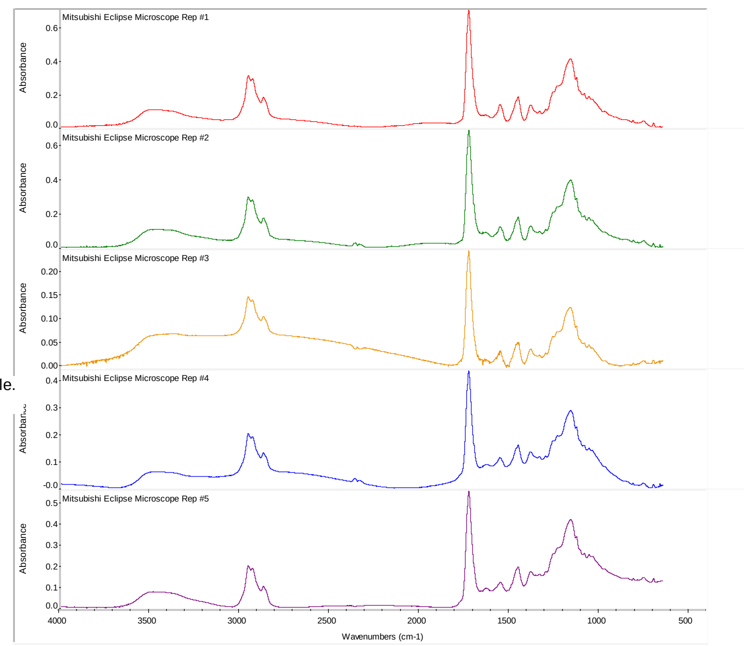
Title: PC006 Mitsubishi Eclipse Microscop

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Clear coat is very thin on this sample.
Paint is also very brittle.



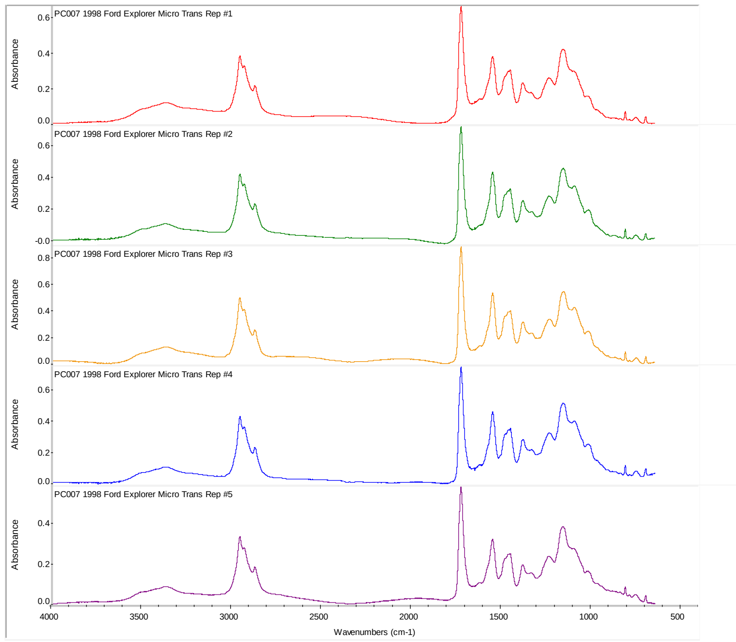
Title: PC007 1998 Ford Explorer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



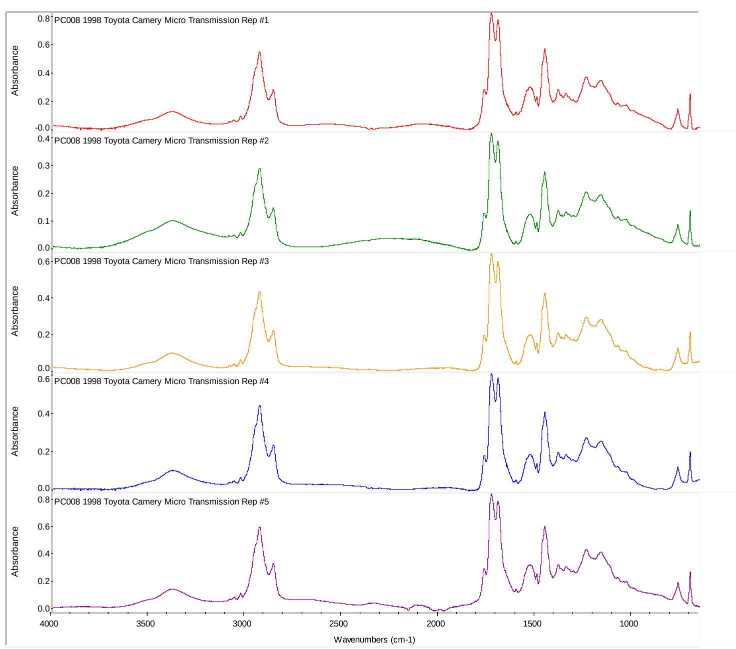
Title: PC008 1998 Toyota Camery

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



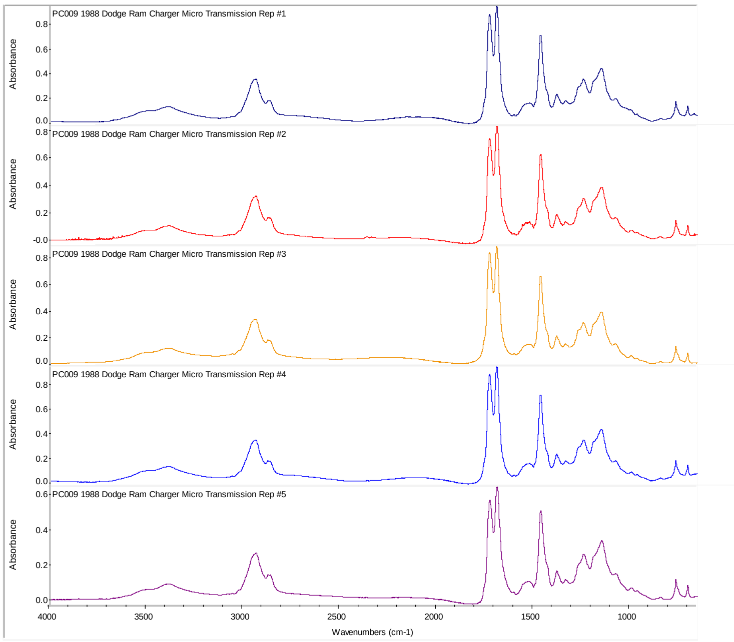
Title: PC009 1988 Dodge Ram Charger

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



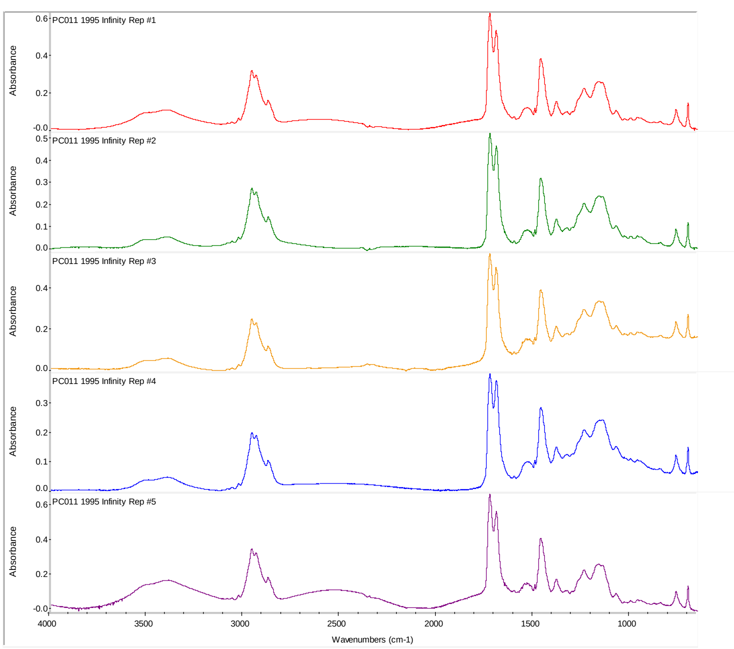
Title: PC011 1995 Infinity

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



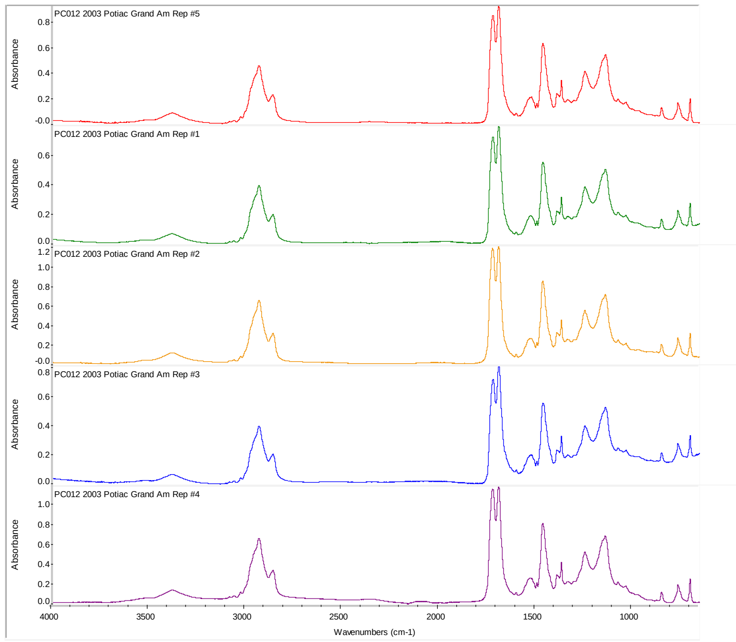
Title: PC012 2003 Potiac Grand Am

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



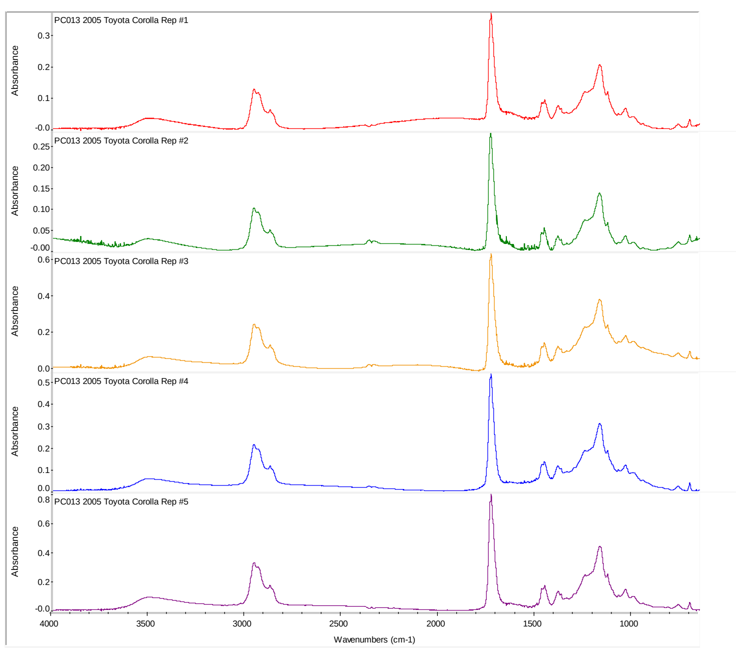
Title: PC013 2005 Toyota Corolla

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



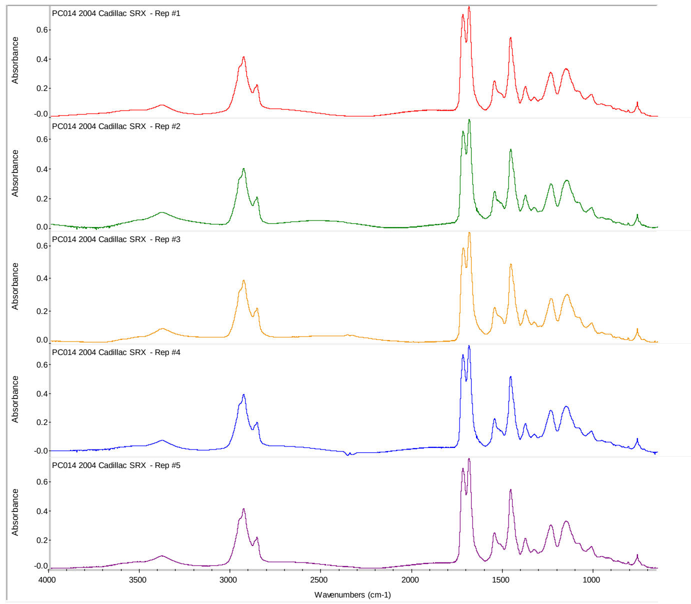
Title: PC014 2004 Cadillac SRX

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



Title: PC015 2000 Chrysler Sebring

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Only clear coat to date that has pigment through out the clear coat layer.

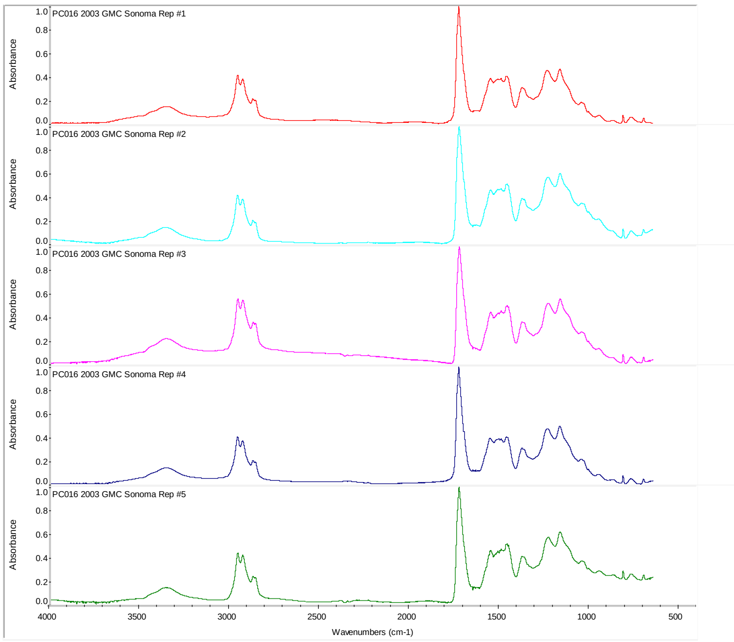
Title: PC016 2003 GMC Sonoma

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



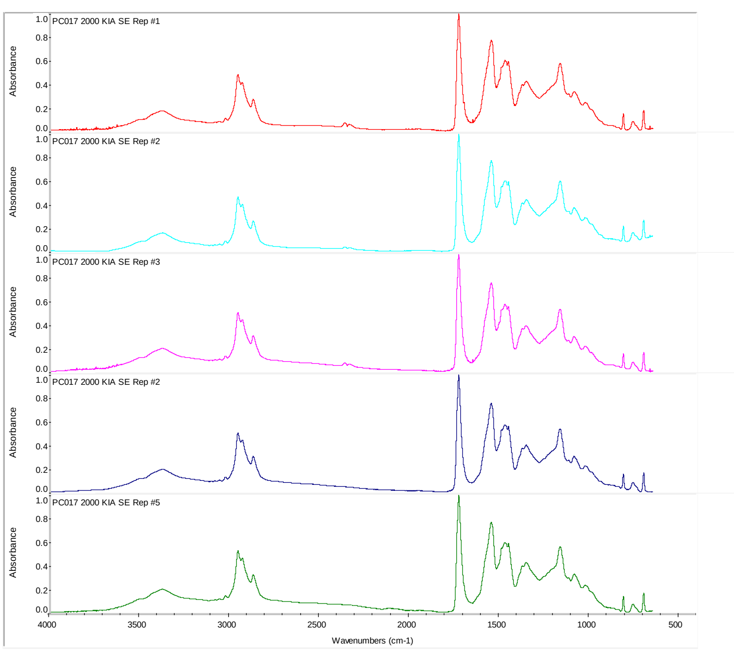
Title: PC017 2000 KIA SE

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



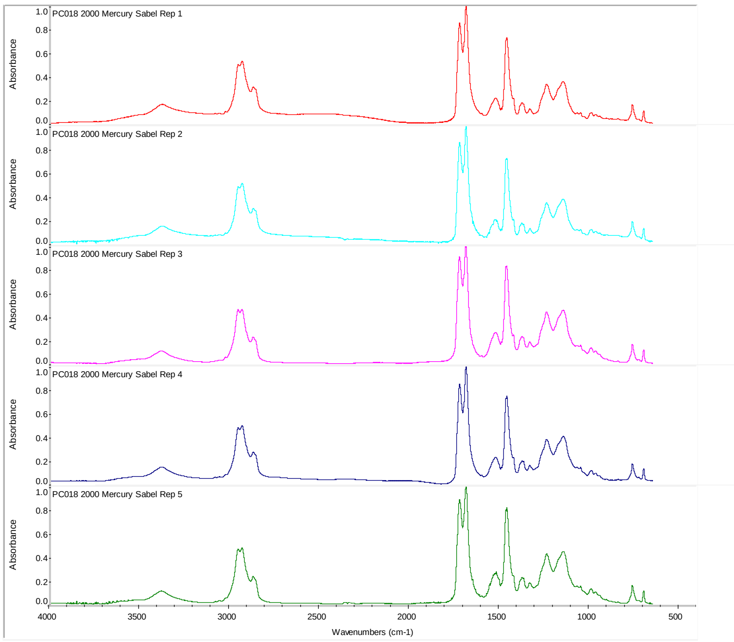
Title: PC018 2000 Mercury Sabel

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



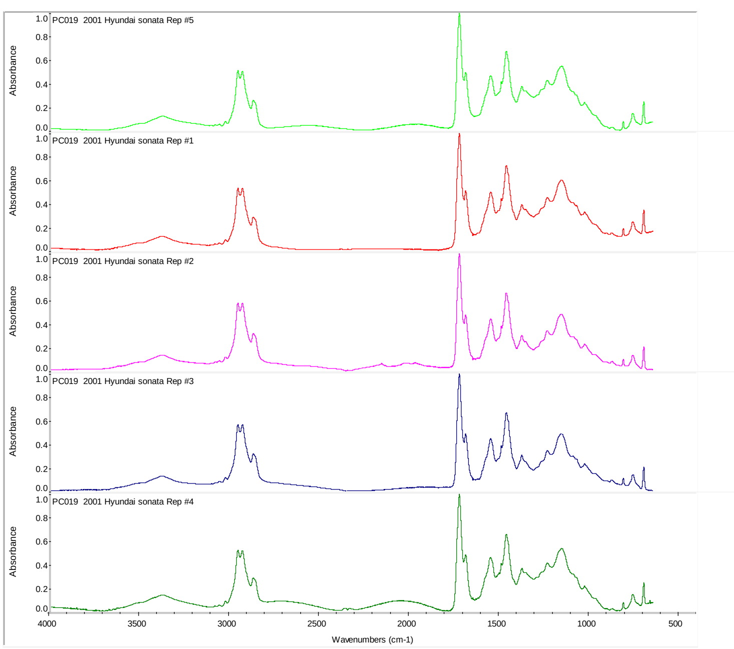
Title: PC019 2001 Hyundai sonata

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



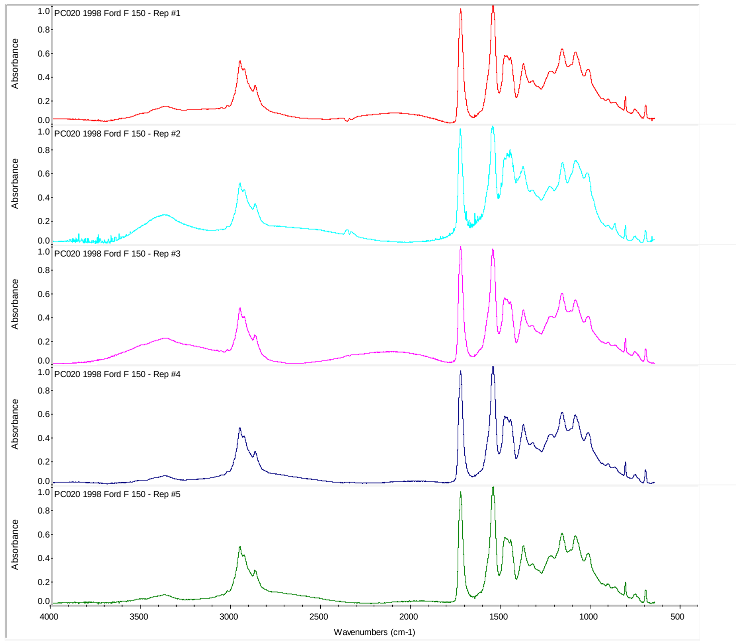
Title: PC020 1998 Ford F 150

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



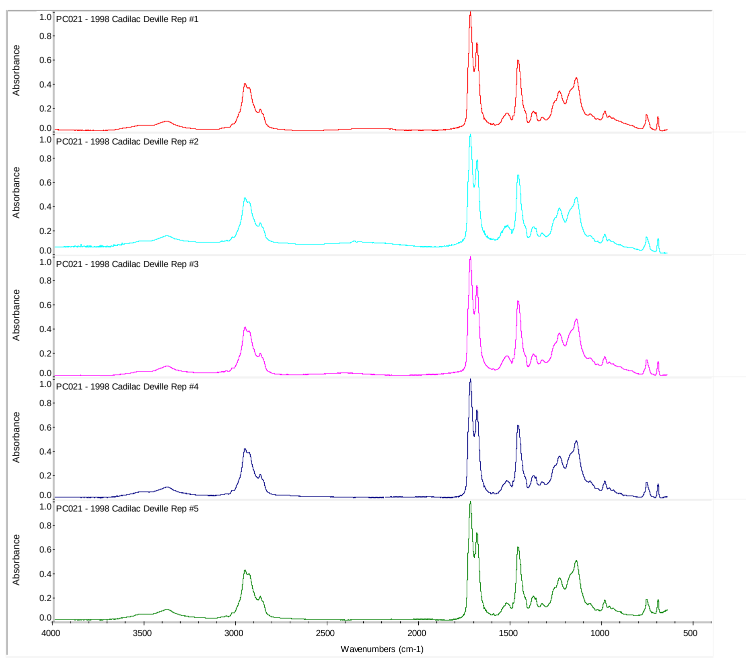
Title: PC021 - 1998 Cadilac Deville

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



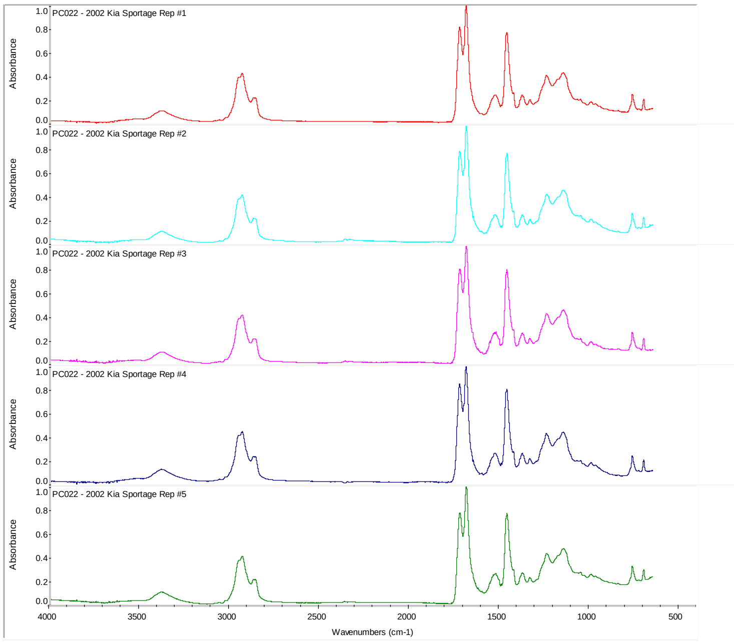
Title: PC022 - 2002 Kia Sportage

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



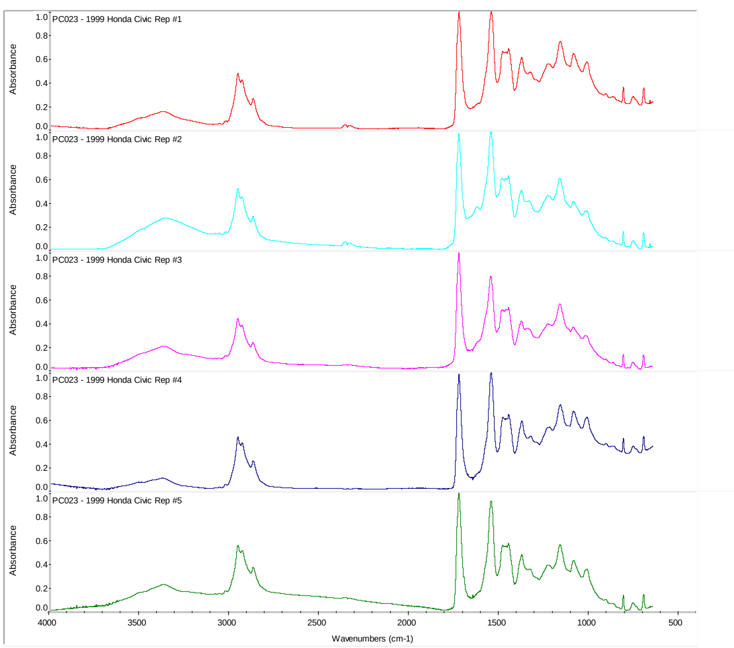
Title: PC023 - 1999 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



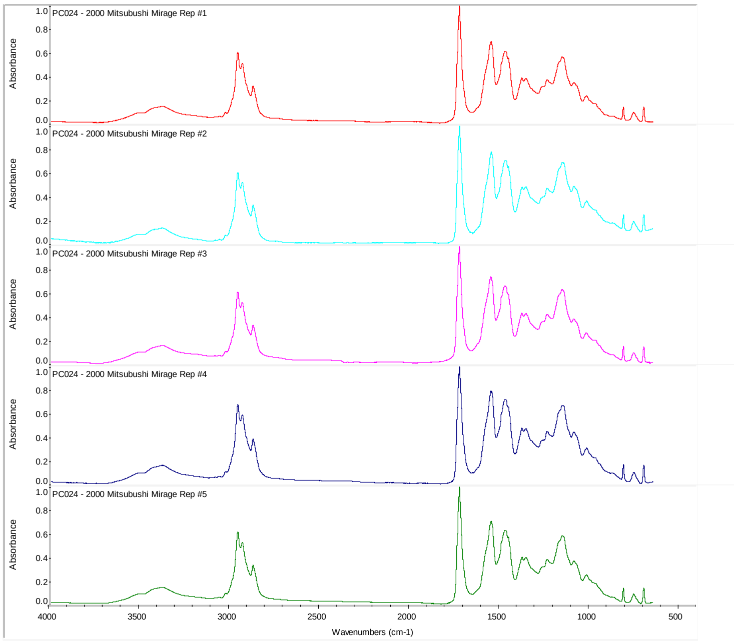
Title: PC024 - 2000 Mitsubishi Mirage

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



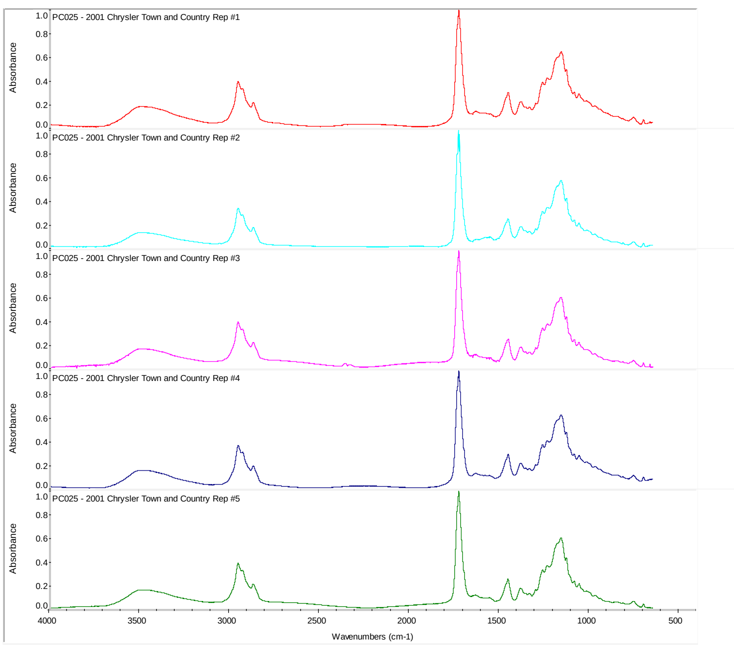
Title: PC025 - 2001 Chrysler Town and Country

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



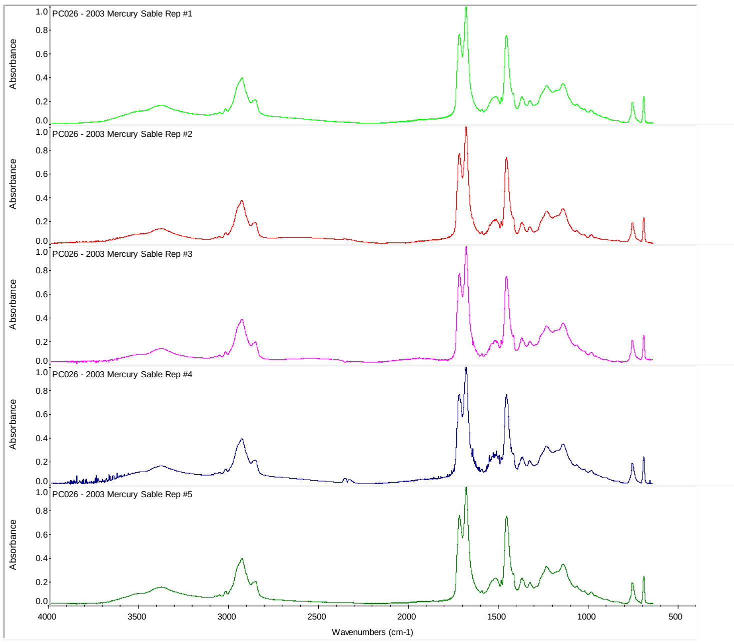
Title: PC026 - 2003 Mercury Sable

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



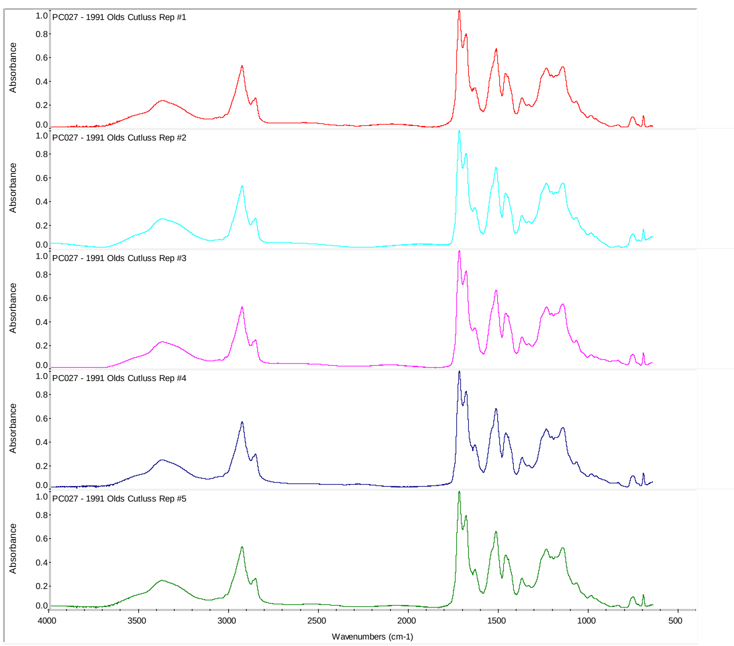
Title: PC027 - 1991 Olds Cutluss

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



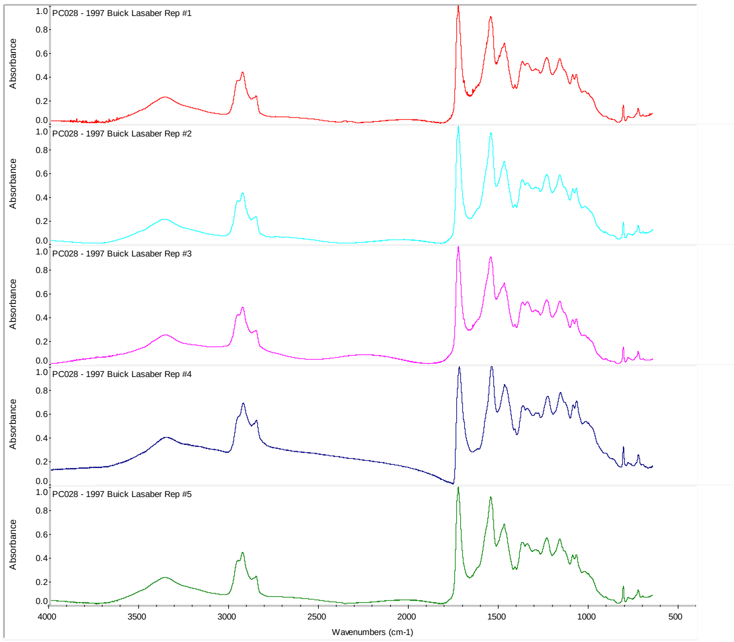
Title: PC028 - 1997 Buick Lasaber

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



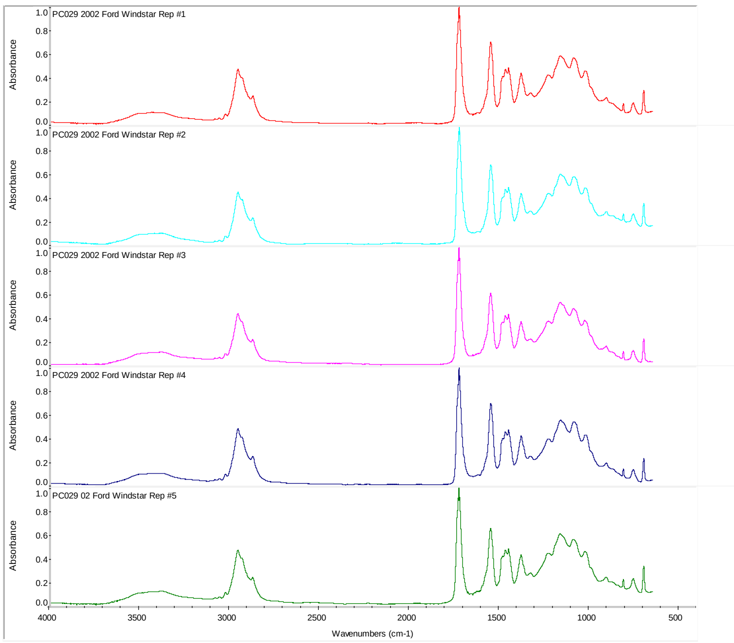
Title: PC029 2002 Ford Windstar

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



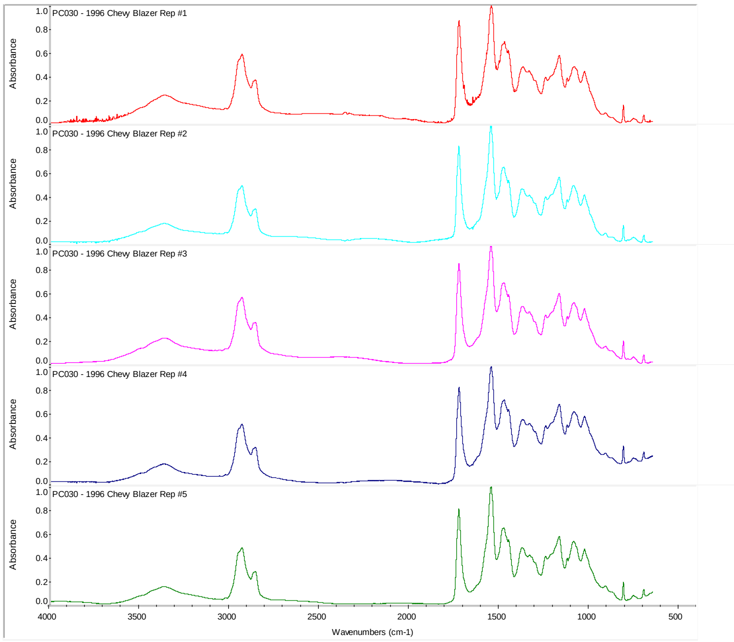
Title: PC030 - 1996 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



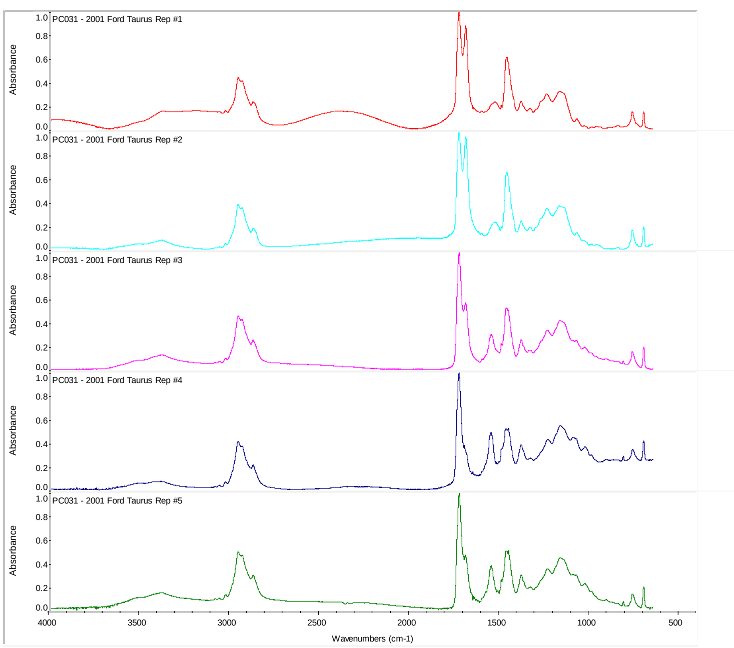
Title: PC031 - 2001 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



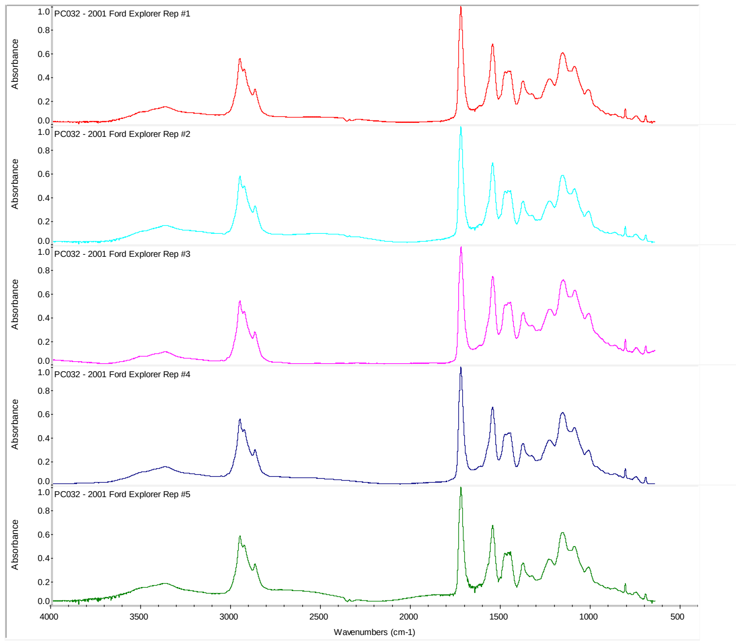
Title: PC032 - 2001 Ford Explorer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



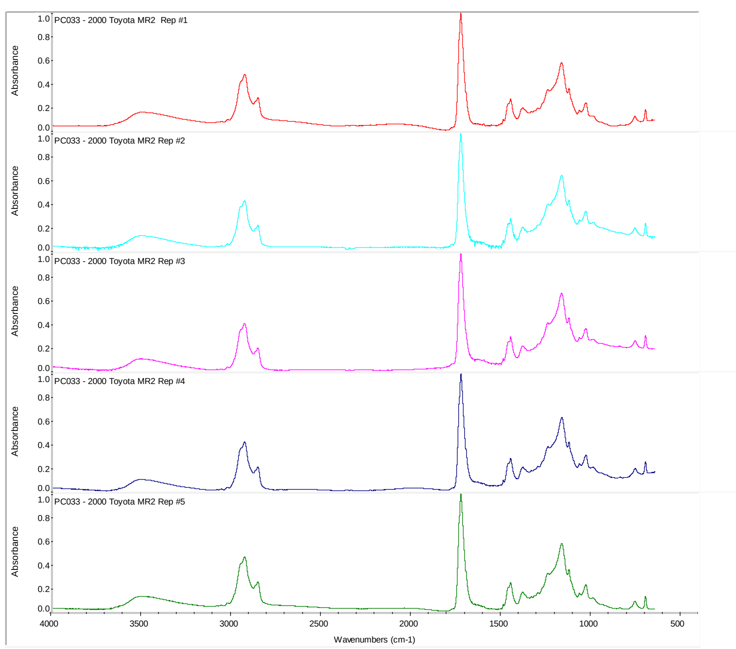
Title: PC033 - 2000 Toyota MR2

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



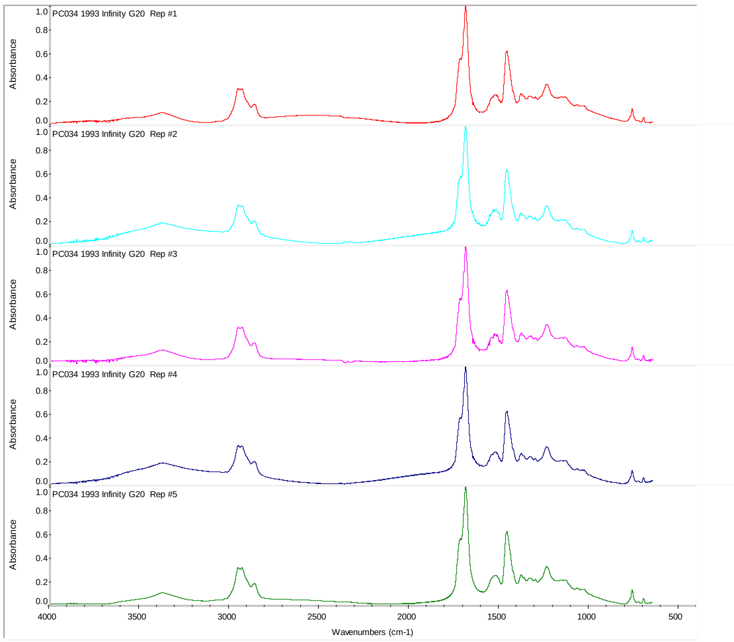
Title: PC034 1993 Infinity G20

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



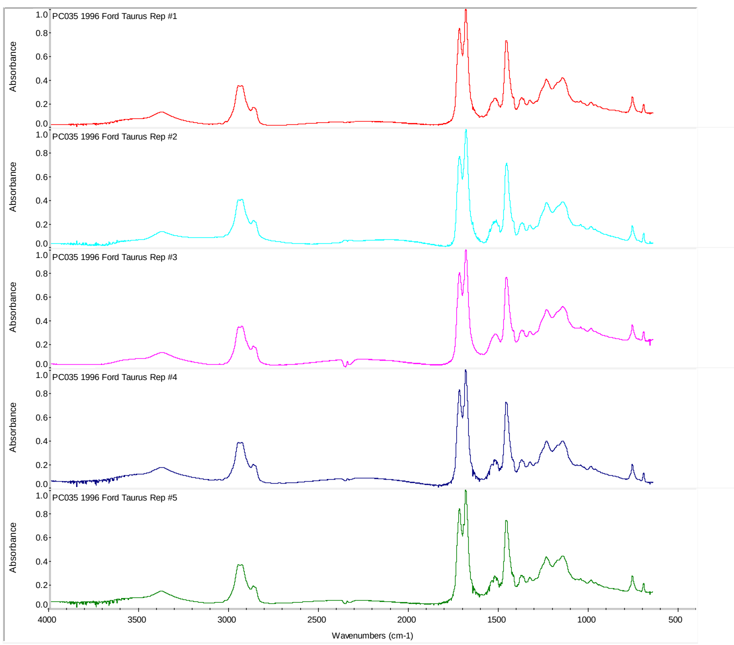
Title: PC035 1996 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



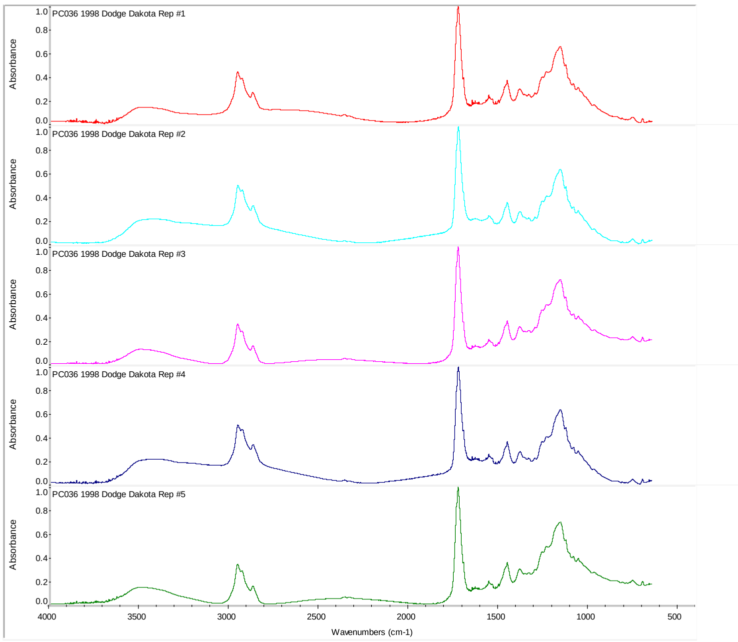
Title: PC036 1998 Dodge Dakota

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



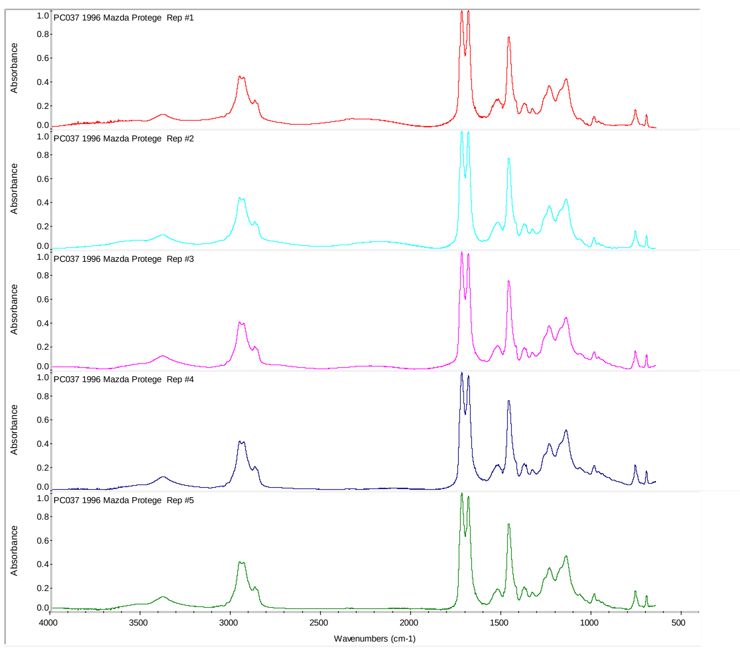
Title: PC037 1996 Mazda Protege

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



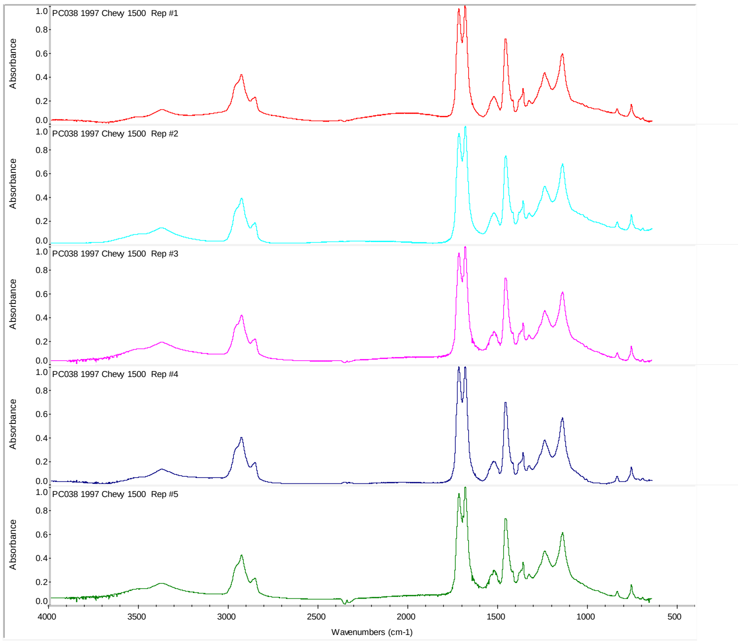
Title: PC038 1997 Chevy 1500

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



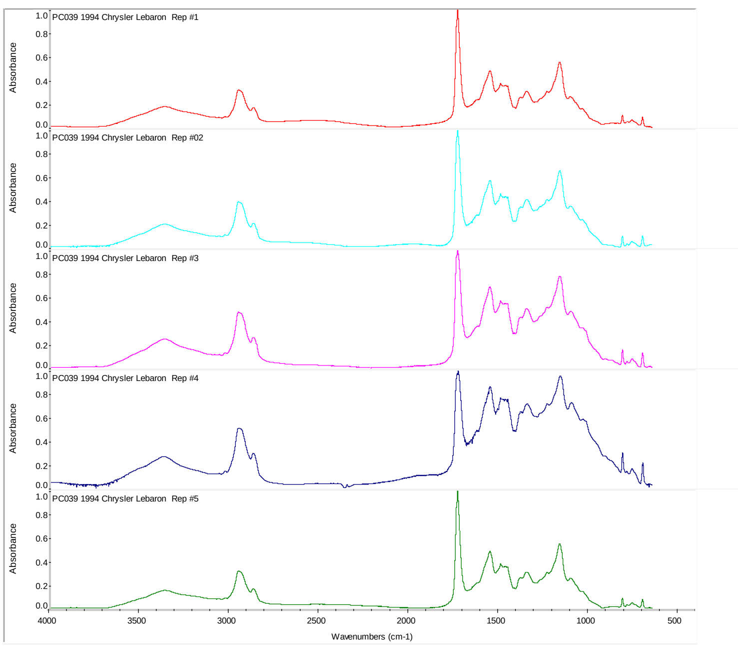
Title: PC039 1994 Chrysler Lebaron

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



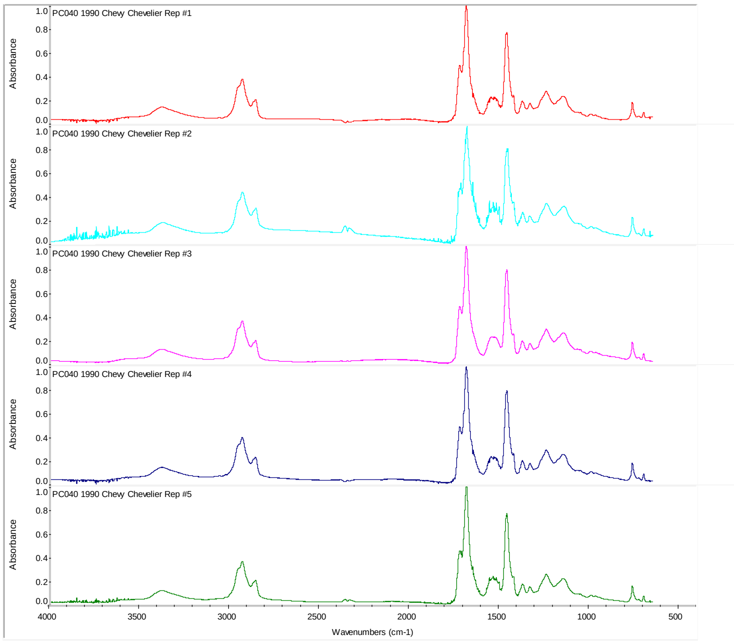
Title: PC040 1990 Chevy Chevelier

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



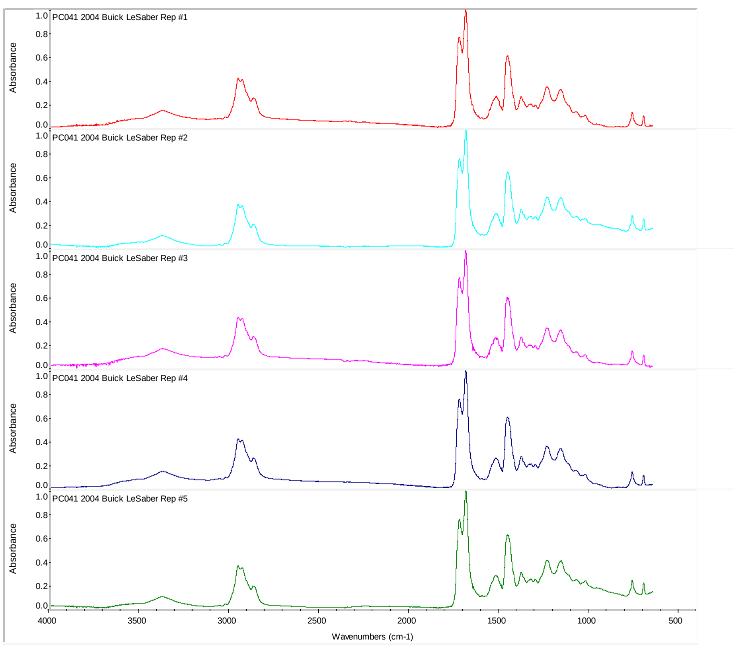
Title: PC041 2004 Buick LeSaber

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



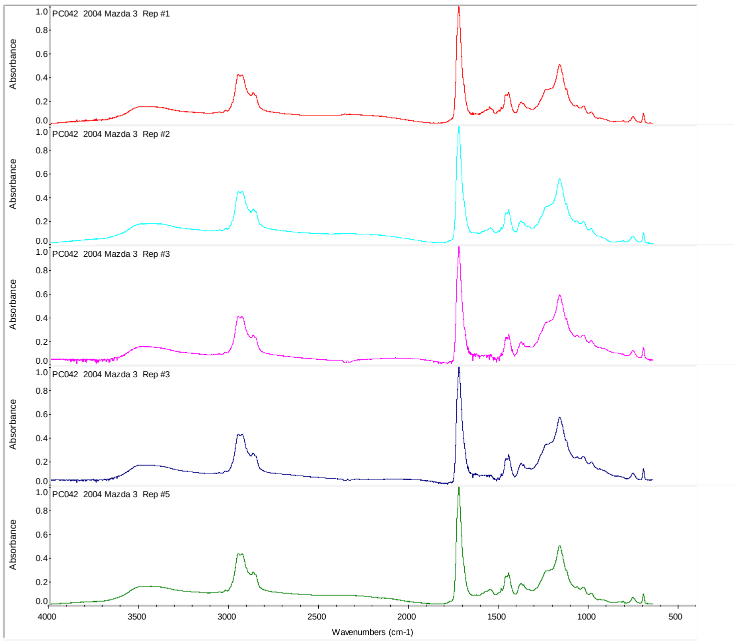
Title: PC042 2004 Mazda 3

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



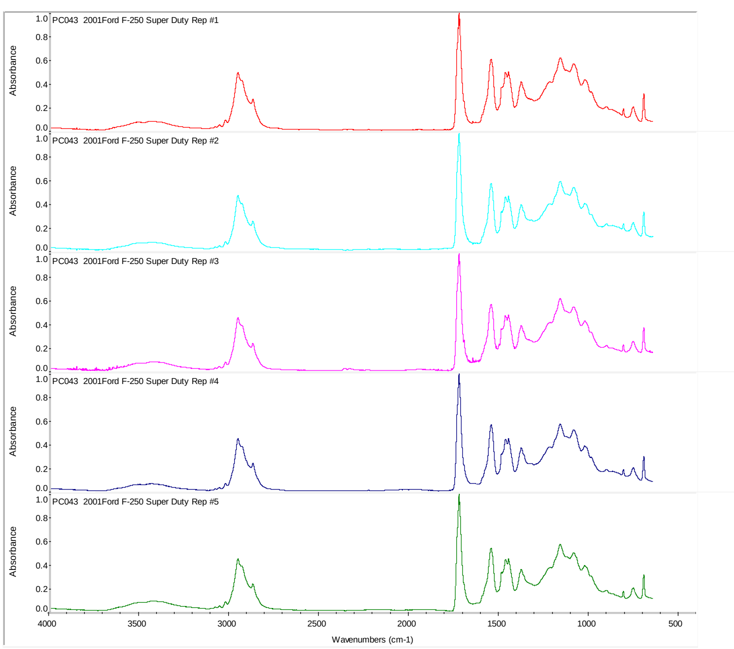
Title: PC043 2001Ford F-250 Super Duty

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



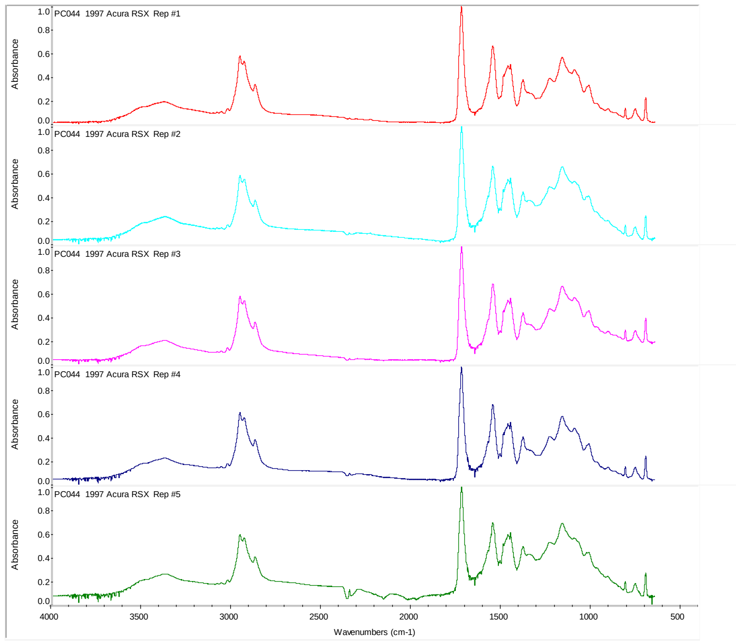
Title: PC044 1997 Acura RSX

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



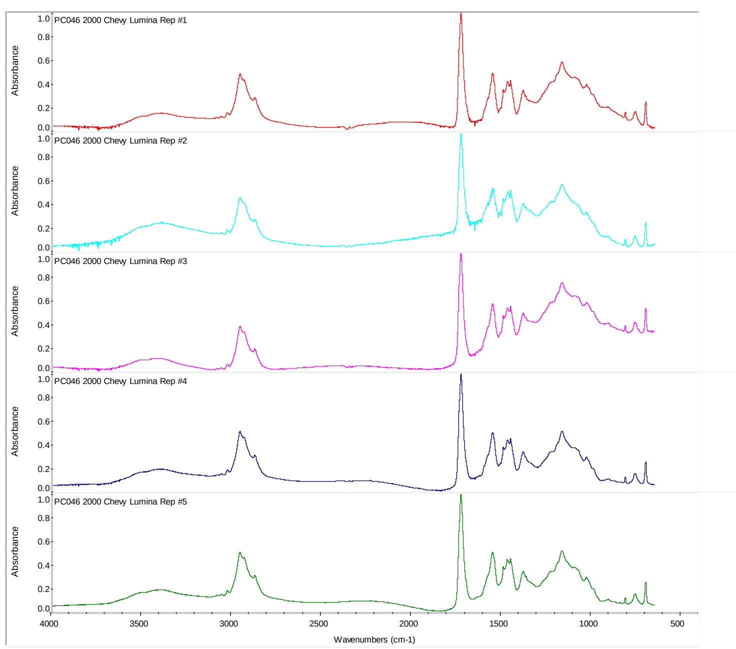
Title: PC046 2000 Chevy Lumina

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



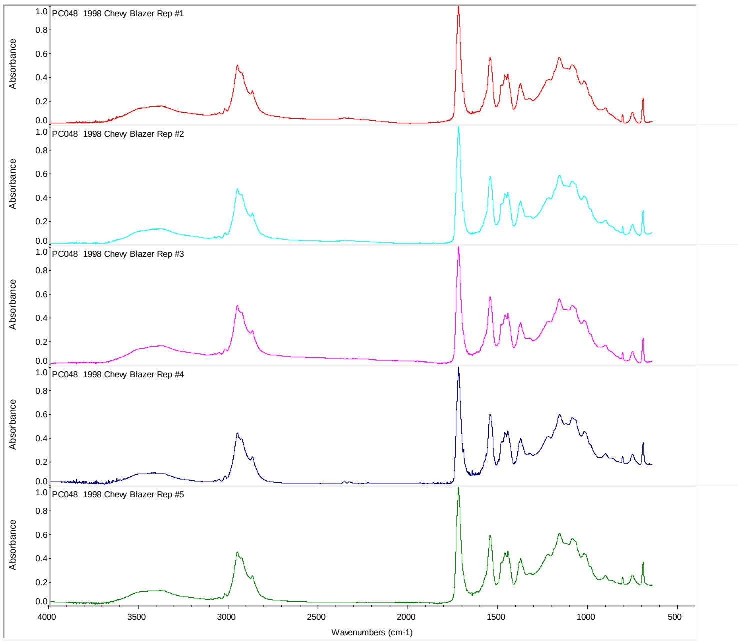
Title: PC048 1998 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



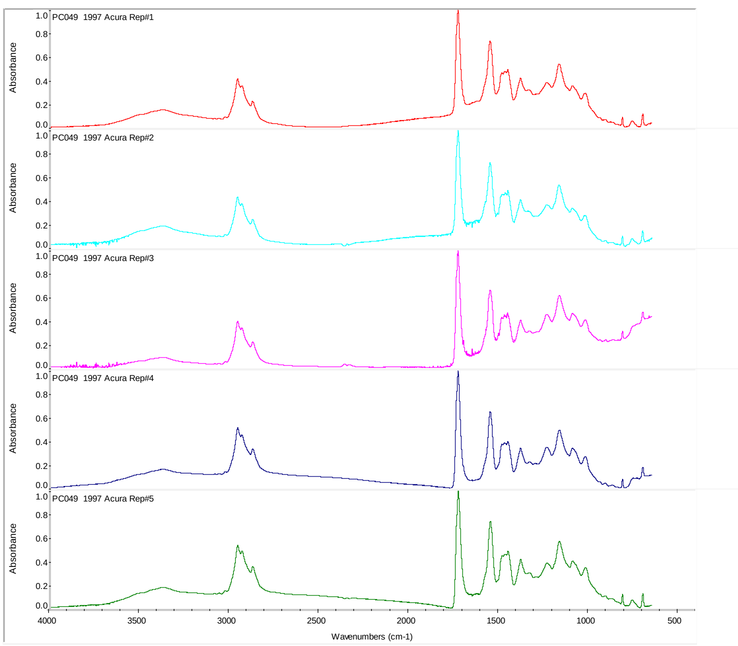
Title: PC049 1997 Acura

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



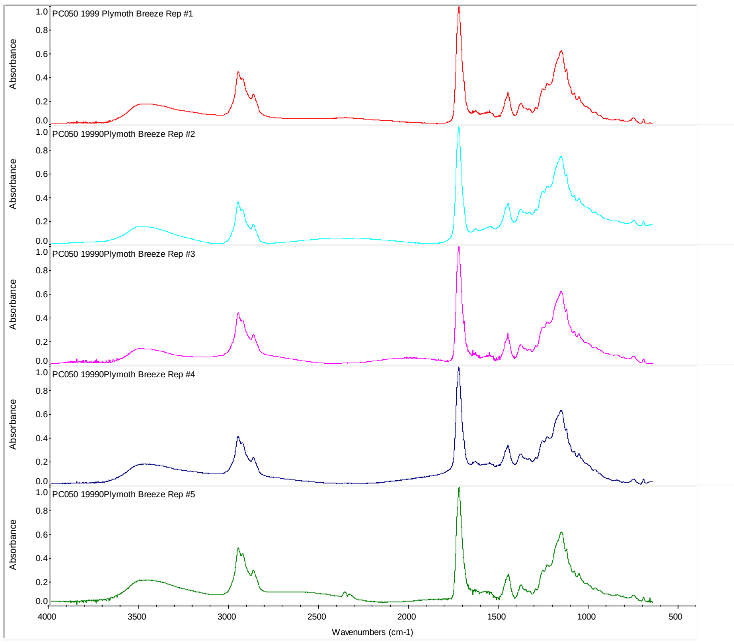
Title: PC050 1999 Plymoth Breeze

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



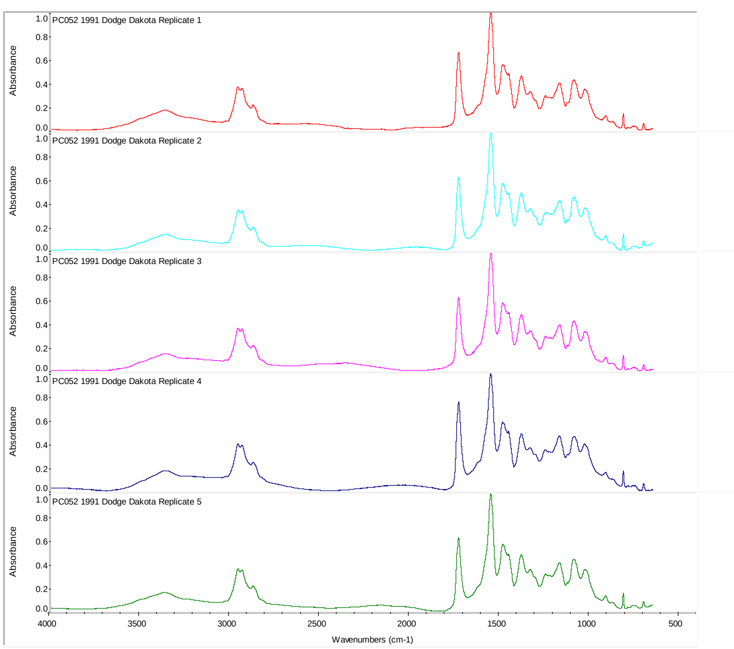
Title: PC052 1991 Dodge Dakota

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



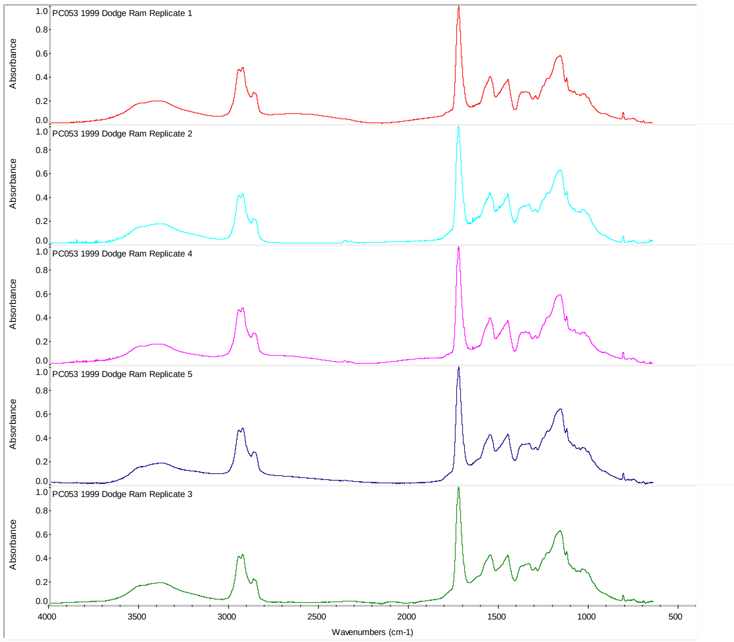
Title: PC053 1999 Dodge Ram

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



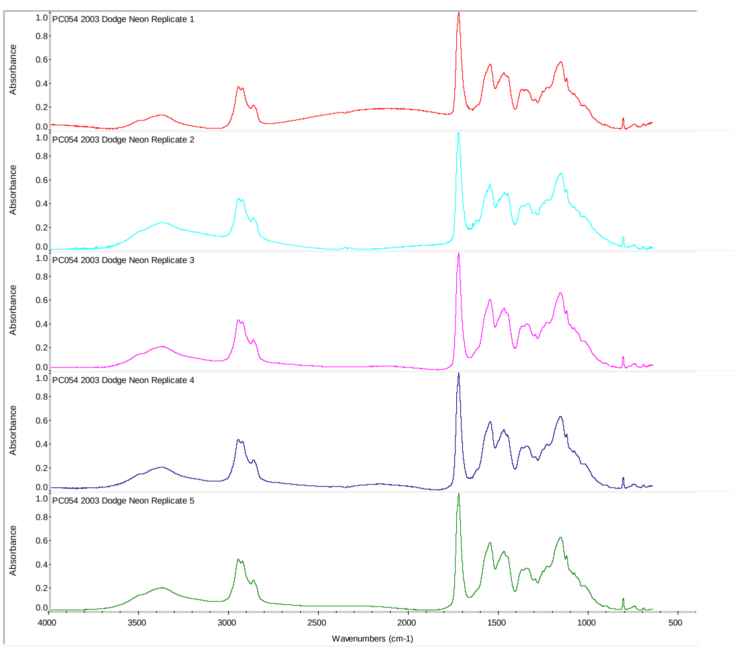
Title: PC054 2003 Dodge Neon

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



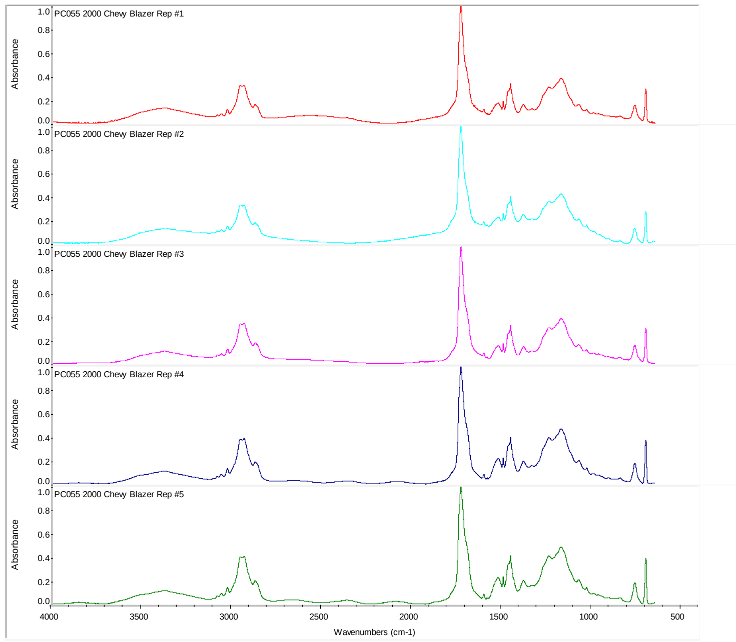
Title: PC055 2000 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



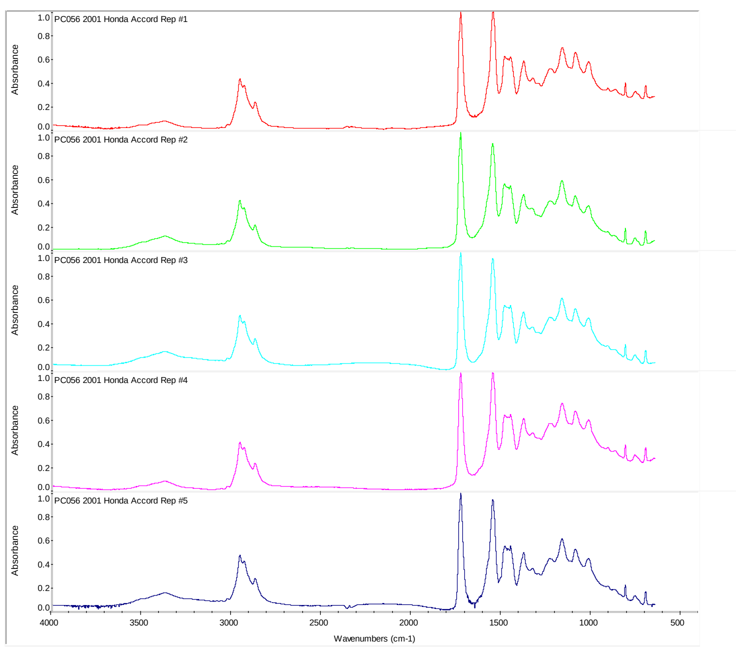
Title: PC056 2001 Honda Accord

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



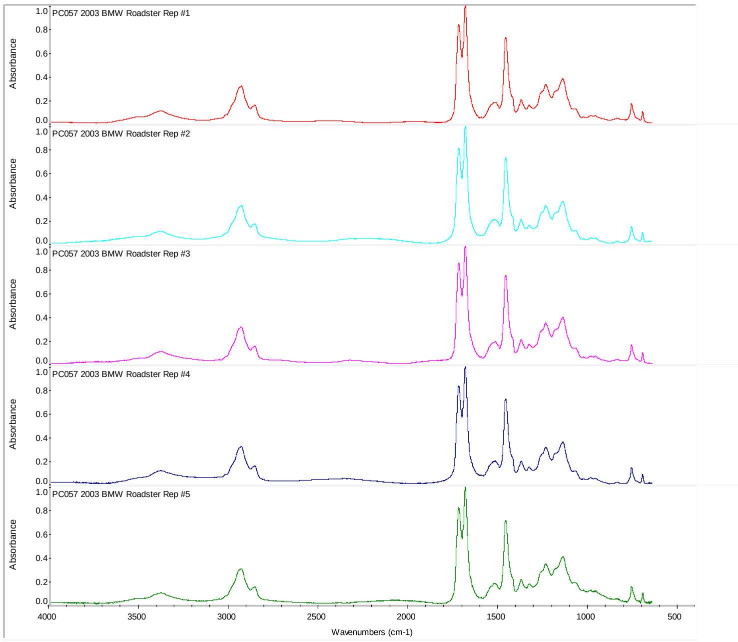
Title: PC057 2003 BMW Roadster

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Most difficult clear coat to cut. Knife didn't want to bite into the polymer.



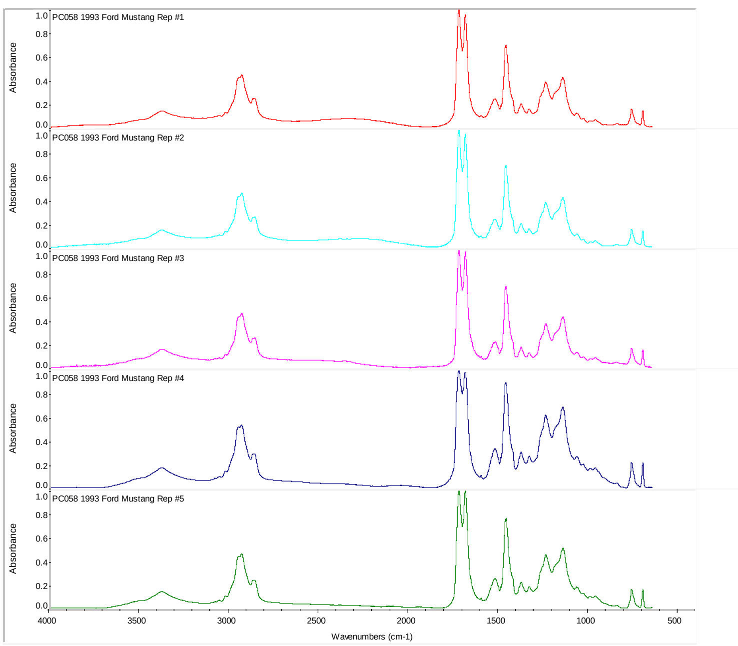
Title: PC058 1993 Ford Mustang

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



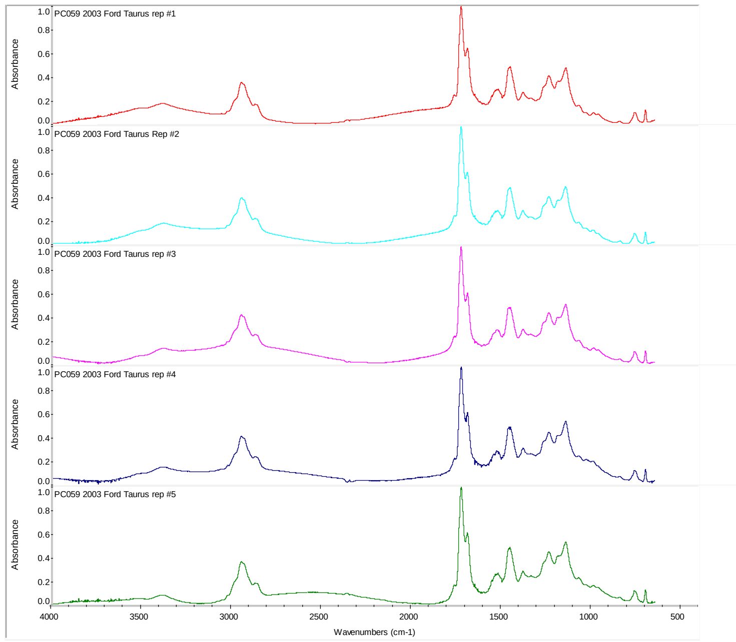
Title: PC059 2003 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Had trouble getting this sample to lay flat. Some constructive/destructive interference.



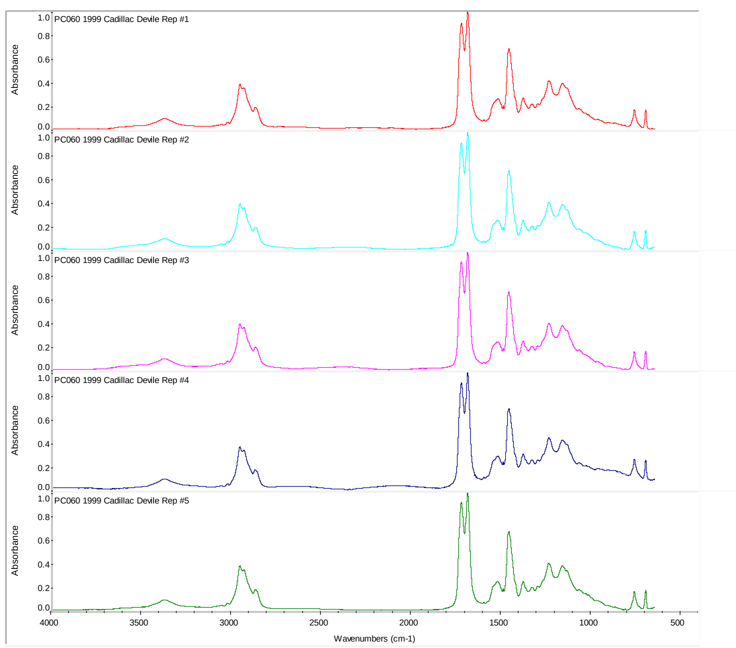
Title: PC060 1999 Cadillac Devile

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



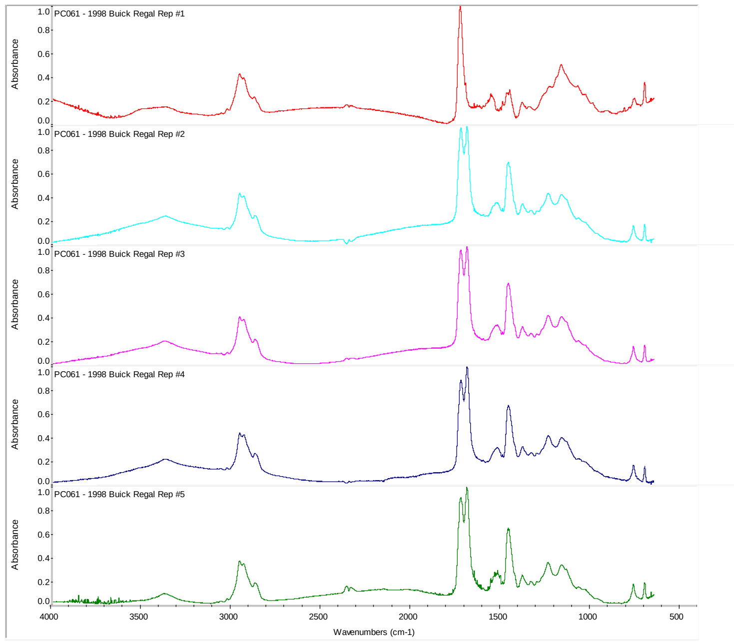
Title: PC061 - 1998 Buick Regal

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



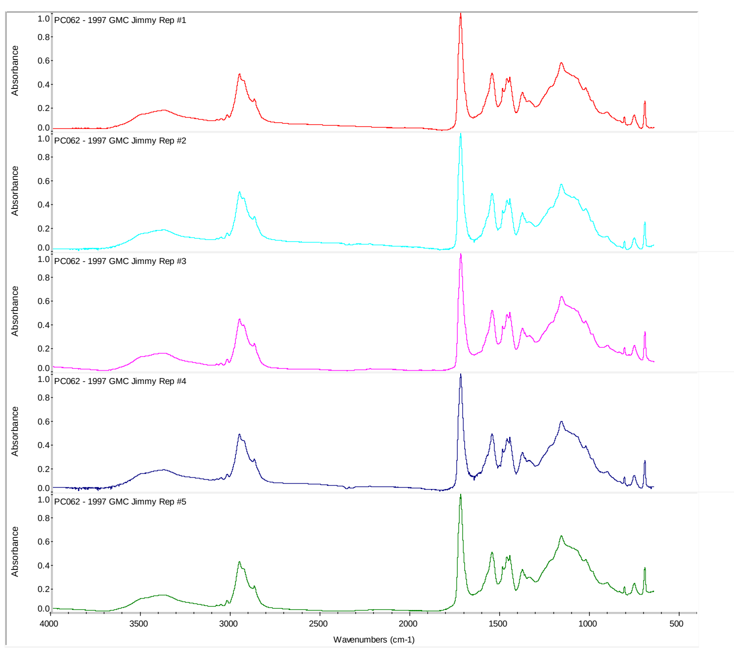
Title: PC062 - 1997 GMC Jimmy

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



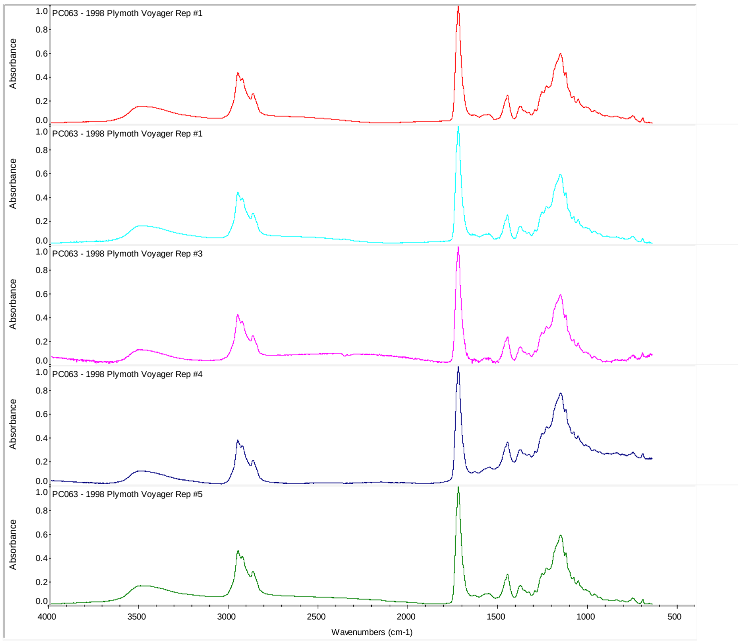
Title: PC063 - 1998 Plymoth Voyager

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



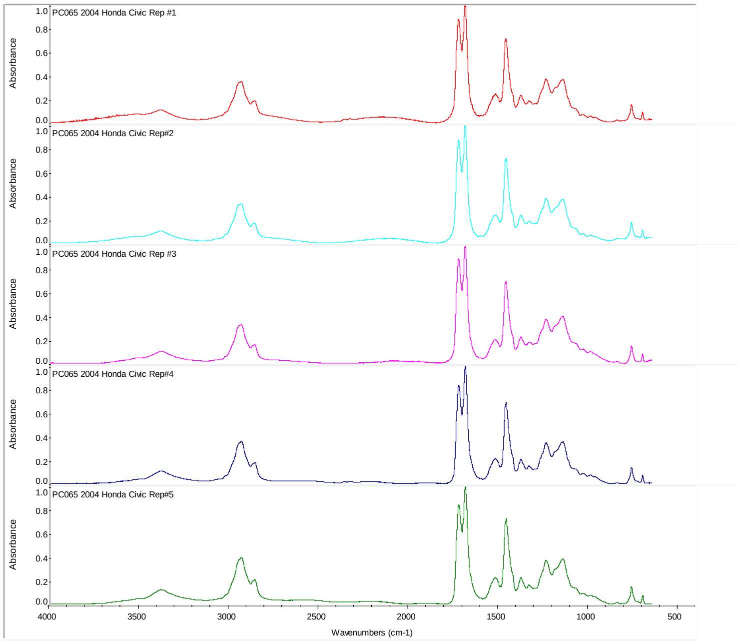
Title: PC065 2004 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



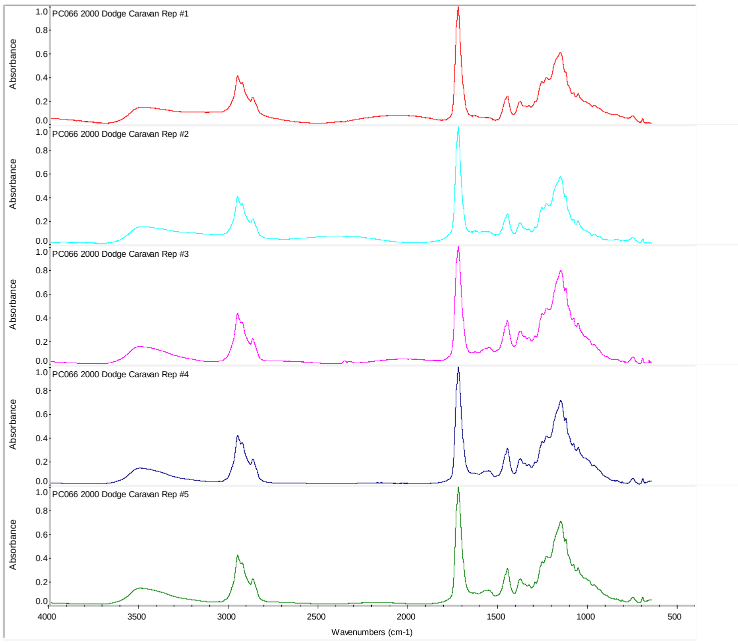
Title: PC066 2000 Dodge Caravan

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



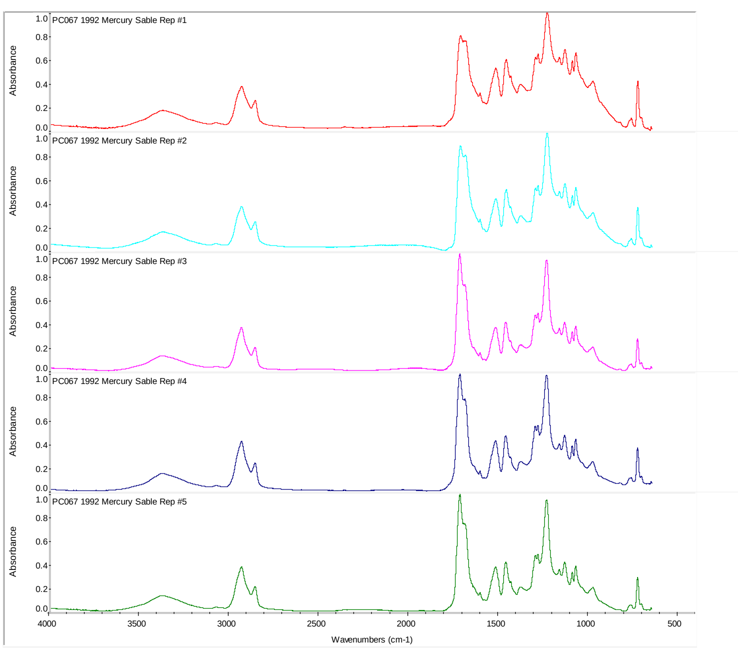
Title: PC067 1992 Mercury Sable

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



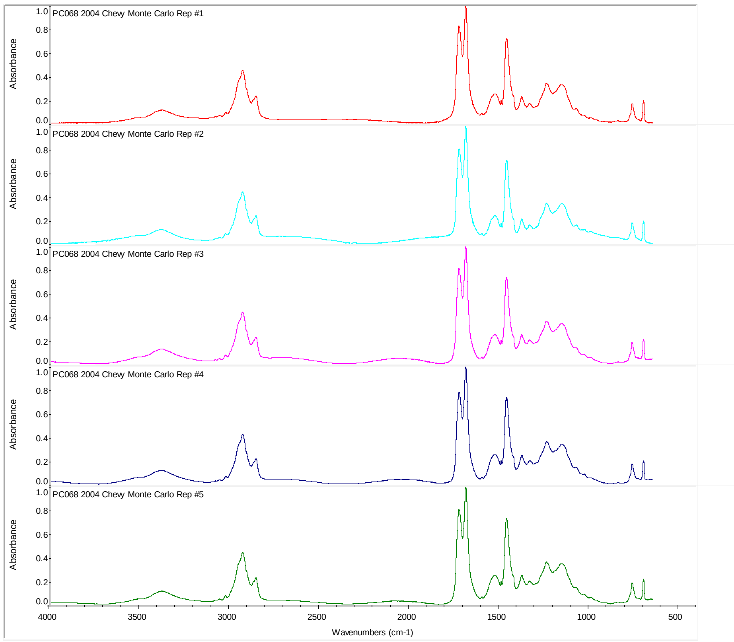
Title: PC068 2004 Chevy Monte Carlo

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



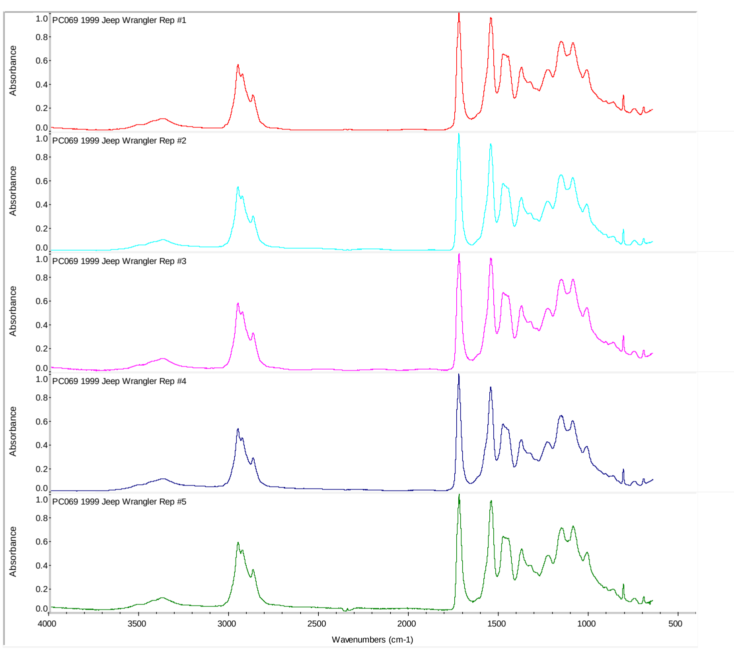
Title: PC069 1999 Jeep Wrangler

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



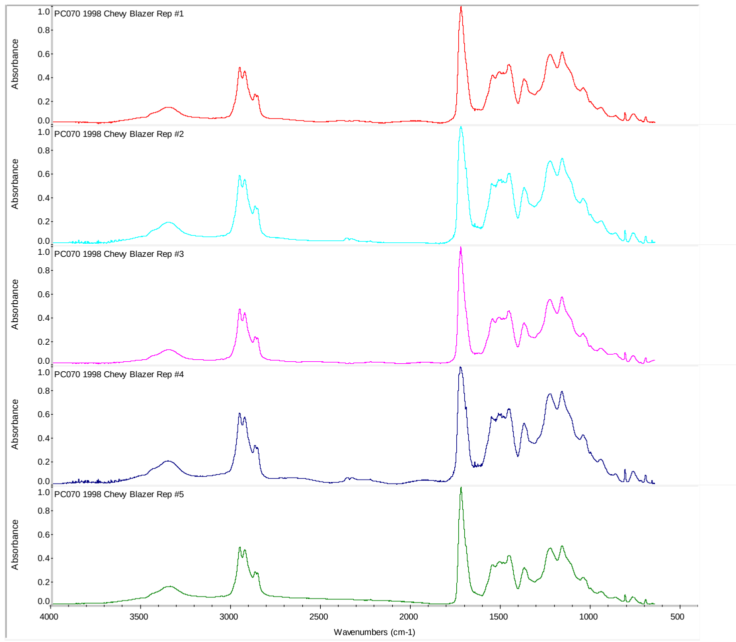
Title: PC070 1998 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



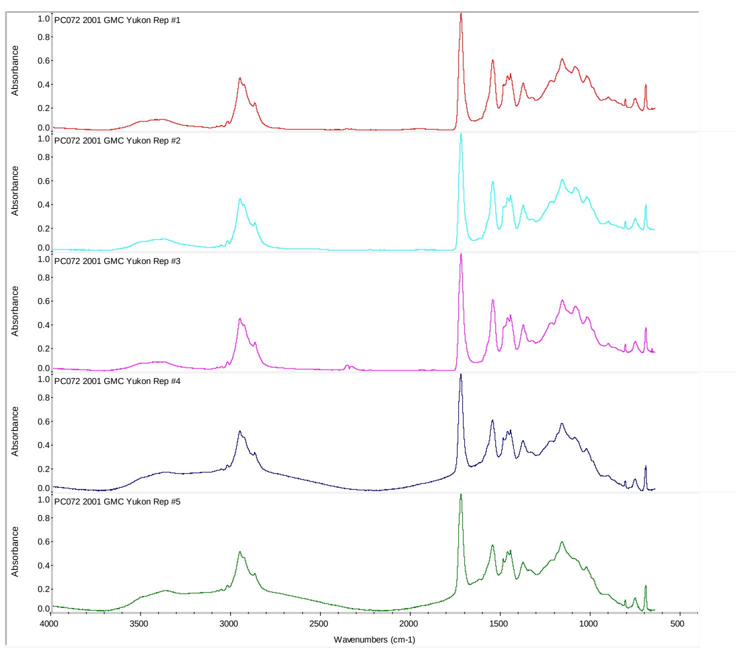
Title: PC072 2001 GMC Yukon

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



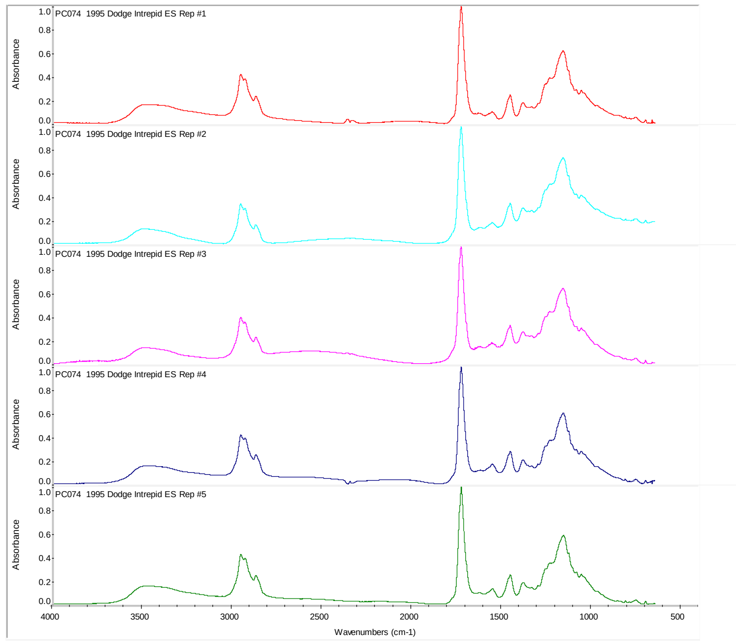
Title: PC074 1995 Dodge Intrepid

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



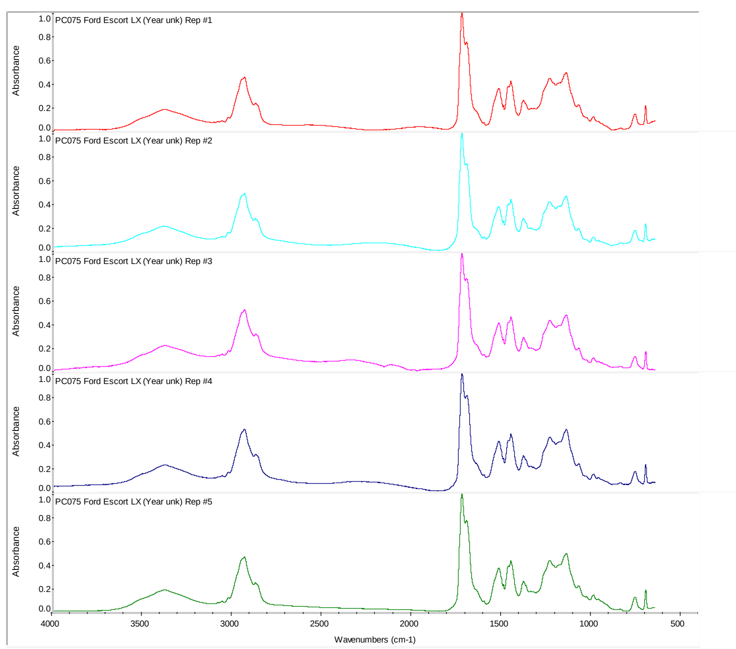
Title: PC075 Ford Escort LX (Year unk)

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



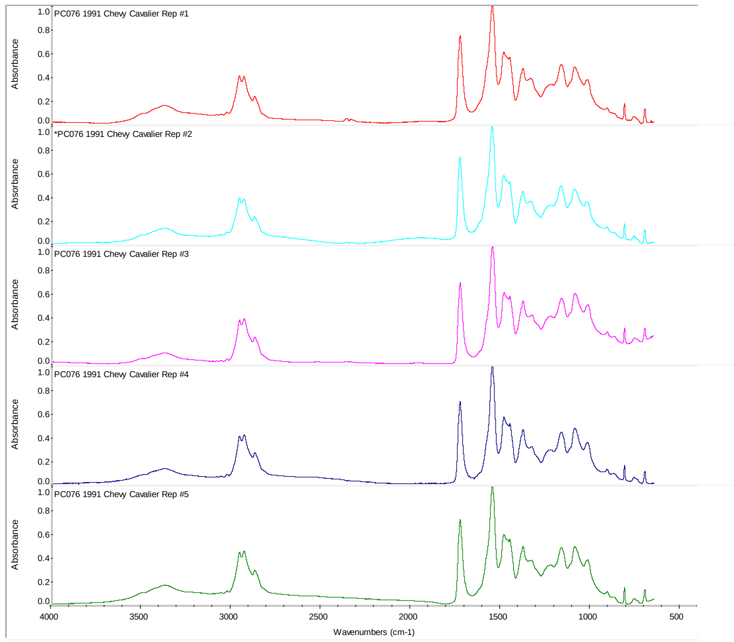
Title: PC076 1991 Chevy Cavalier

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



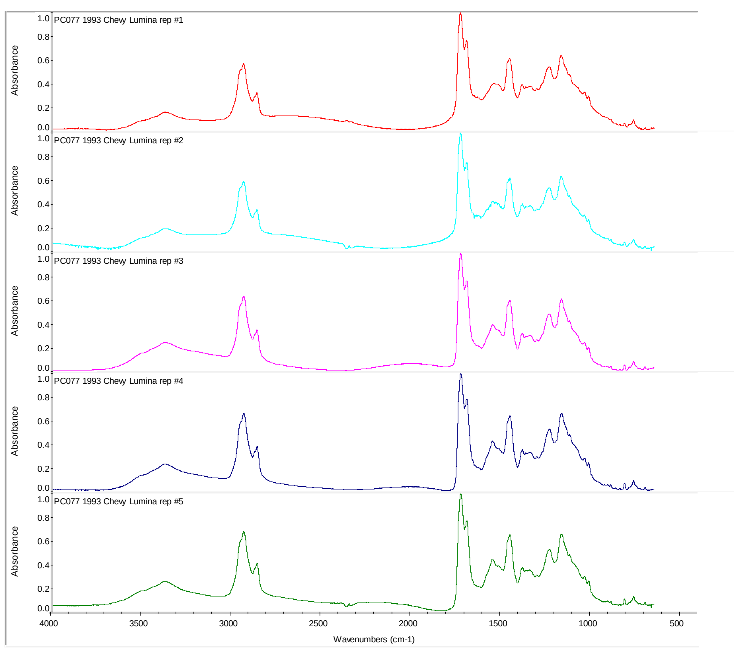
Title: PC077 1993 Chevy Lumina

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



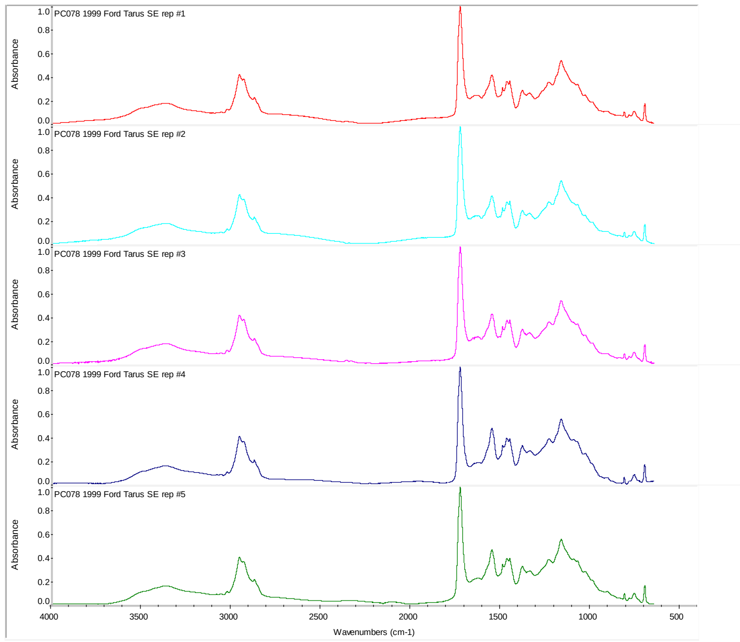
Title: PC078 1999 Ford Tarus SE

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



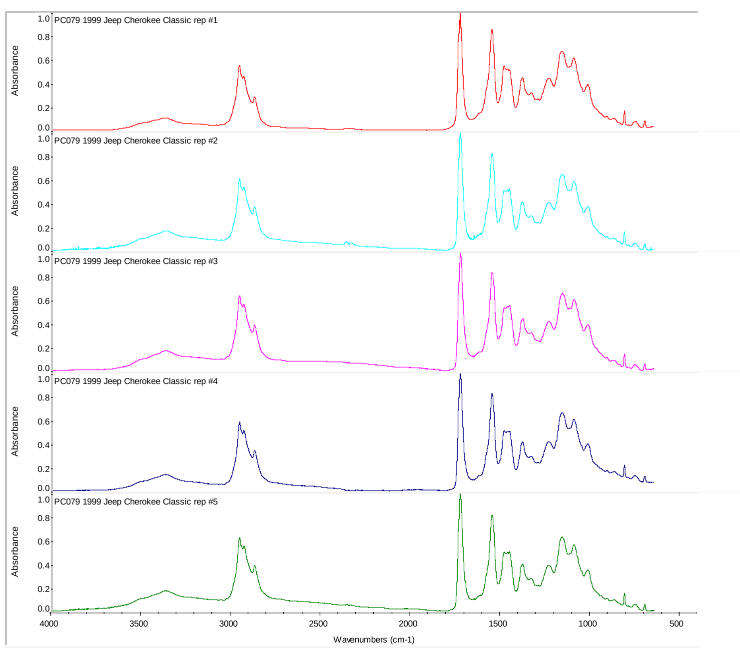
Title: PC079 1999 Jeep Cherokee Classic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



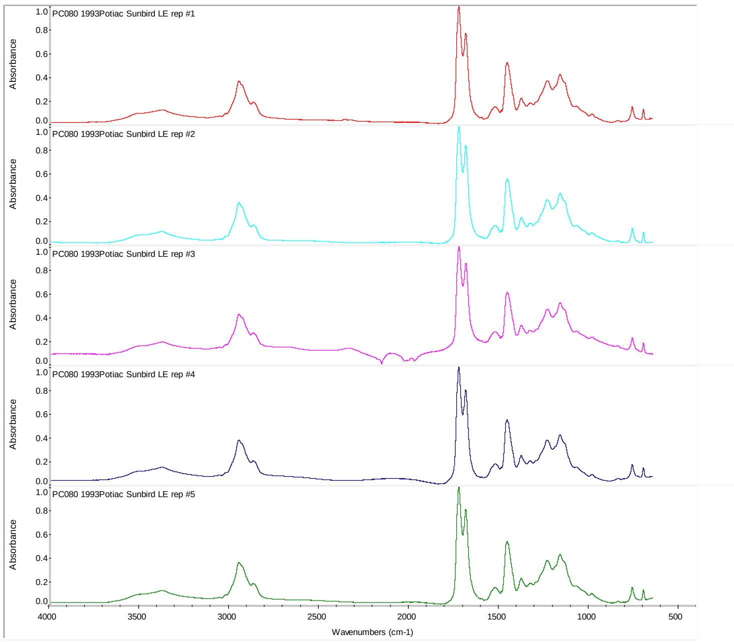
Title: PC080 1993Potiac Sunbird LE

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



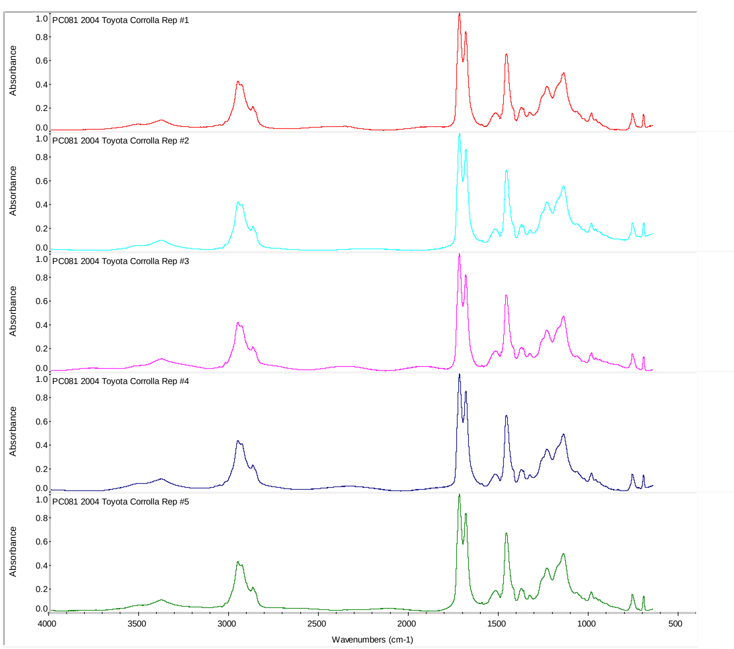
Title: PC081 2004 Toyota Corrolla

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



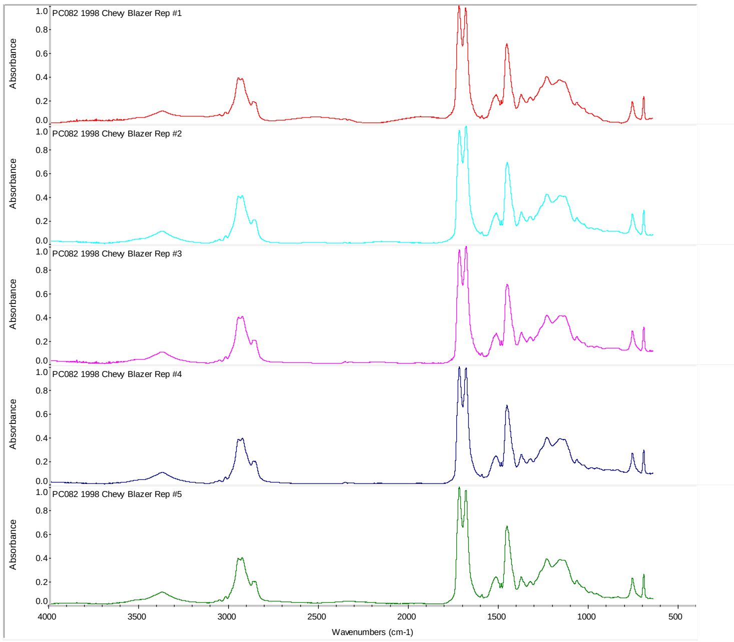
Title: PC082 1998 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



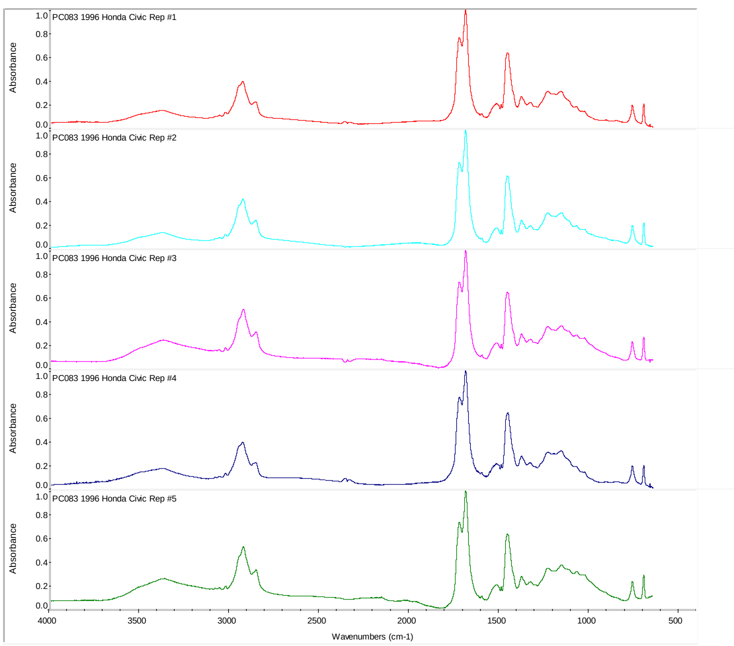
Title: PC083 1996 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



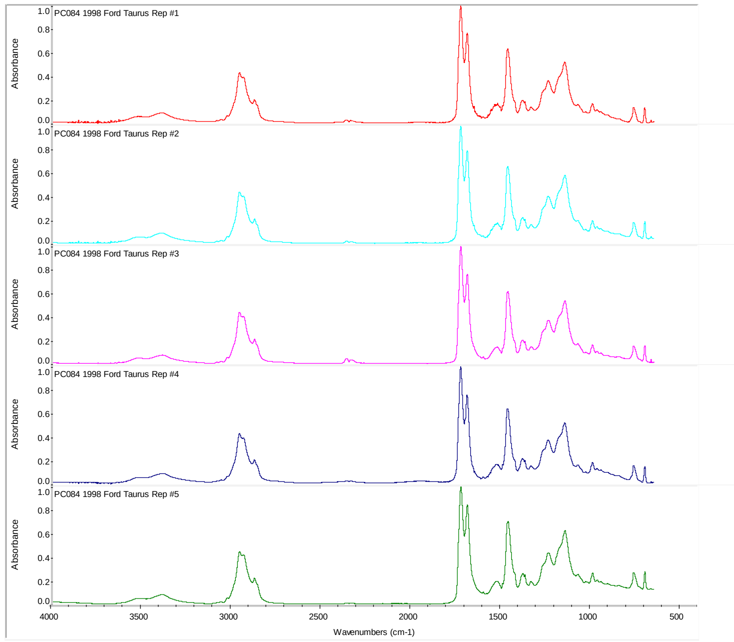
Title: PC084 1998 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



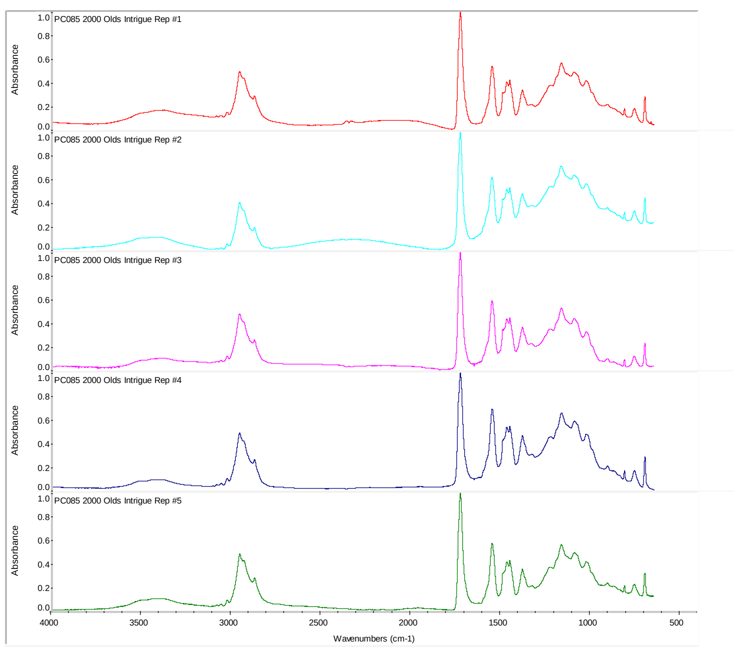
Title: PC085 2000 Olds Intrigue

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



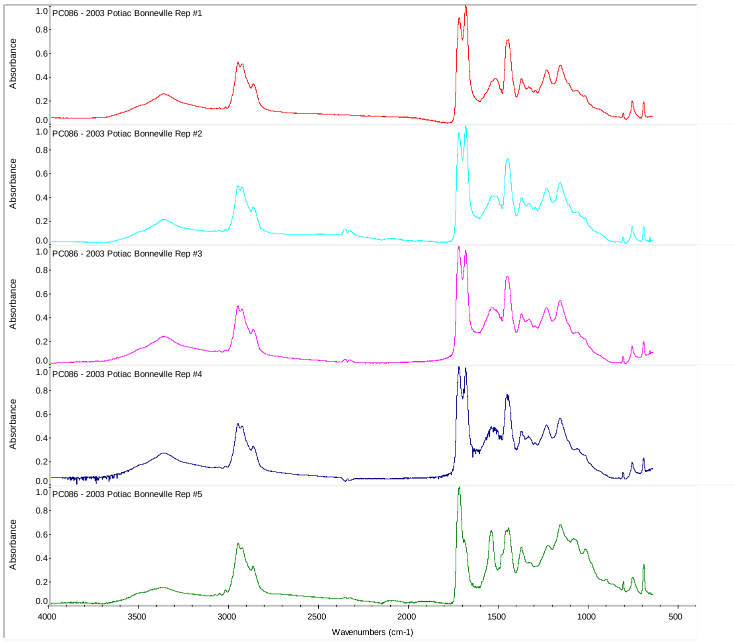
Title: PC086 - 2003 Potiac Bonneville

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



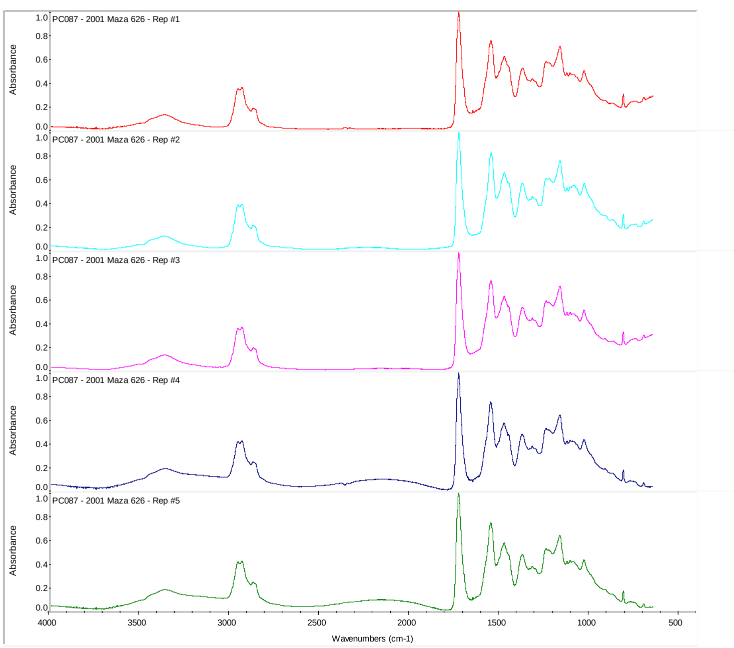
Title: PC087 - 2001 Maza 626

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



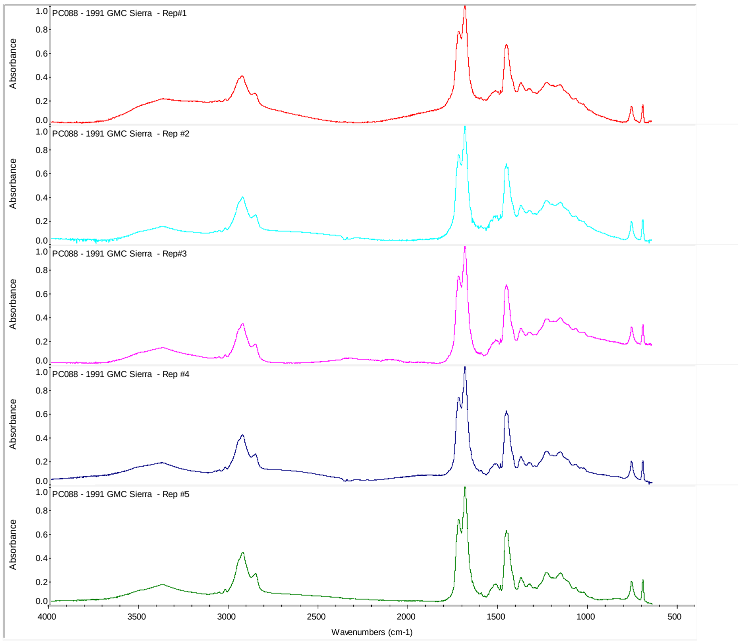
Title: PC088 - 1991 GMC Sierra

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



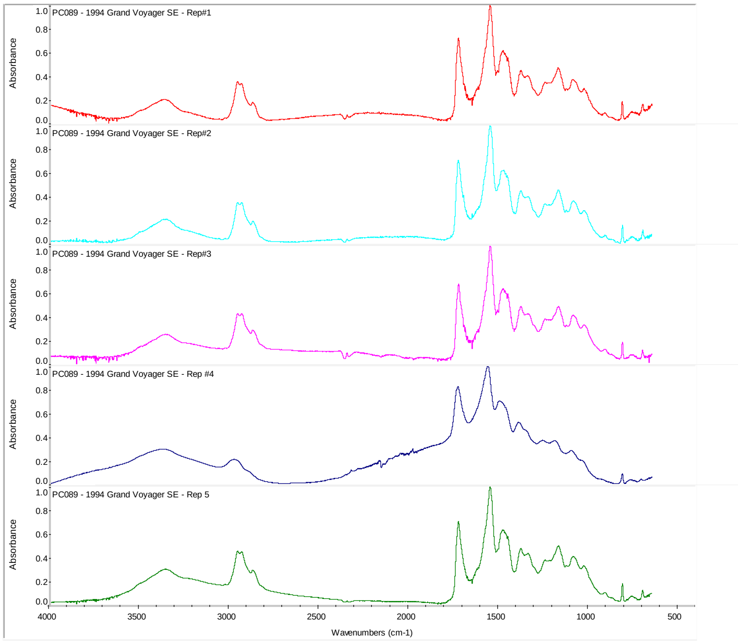
Title: PC089 - 1994 Grand Voyager SE

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



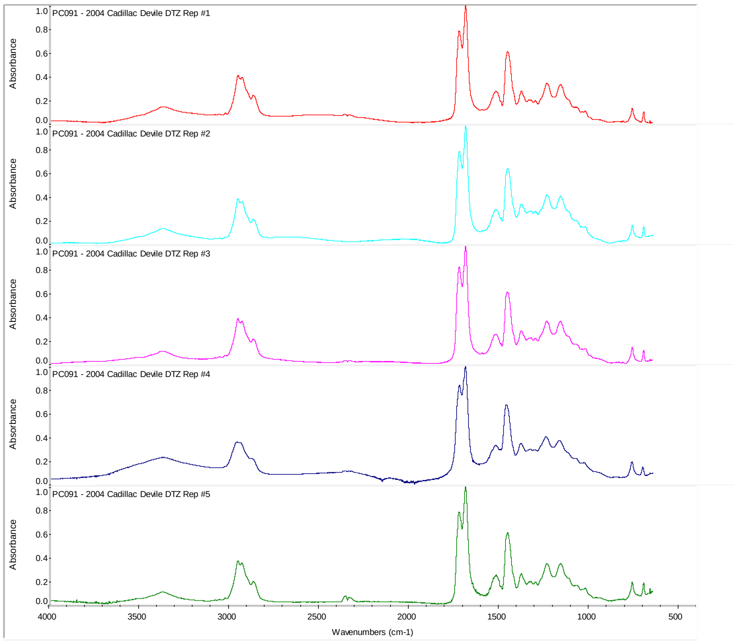
Title: PC091 - 2004 Cadillac Devile DTZ

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



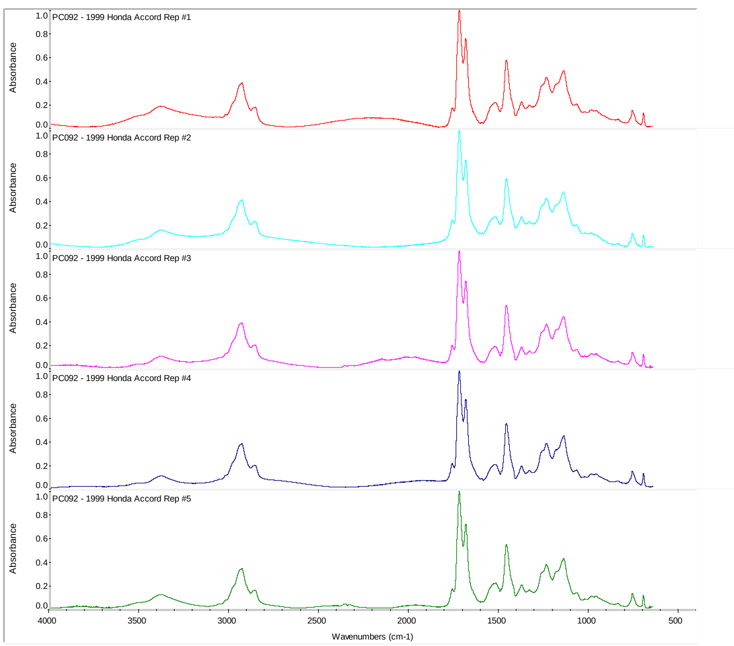
Title: PC092 - 1999 Honda Accord

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



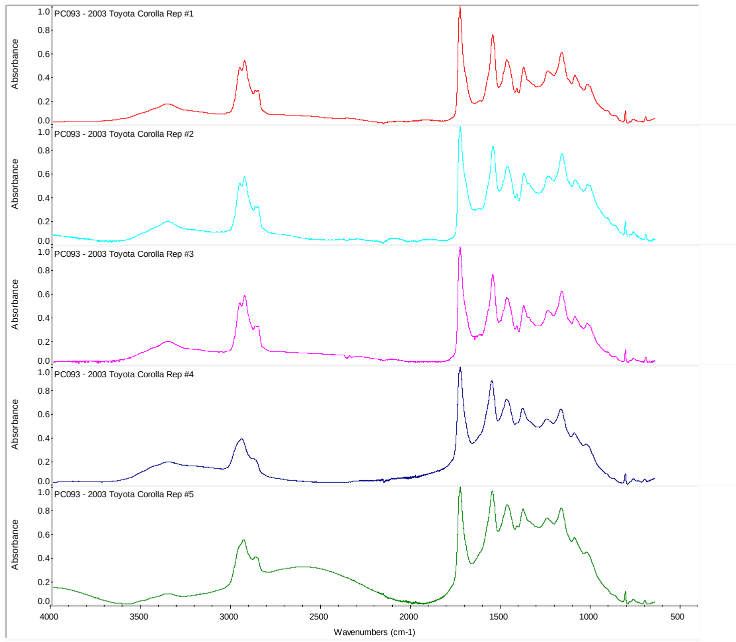
Title: PC093 - 2003 Toyota Corolla

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



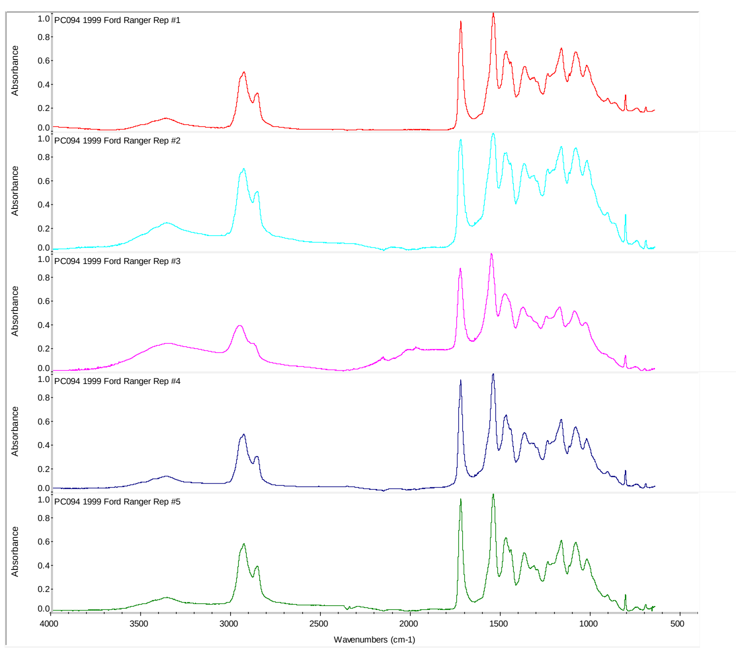
Title: PC094 1999 Ford Ranger

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



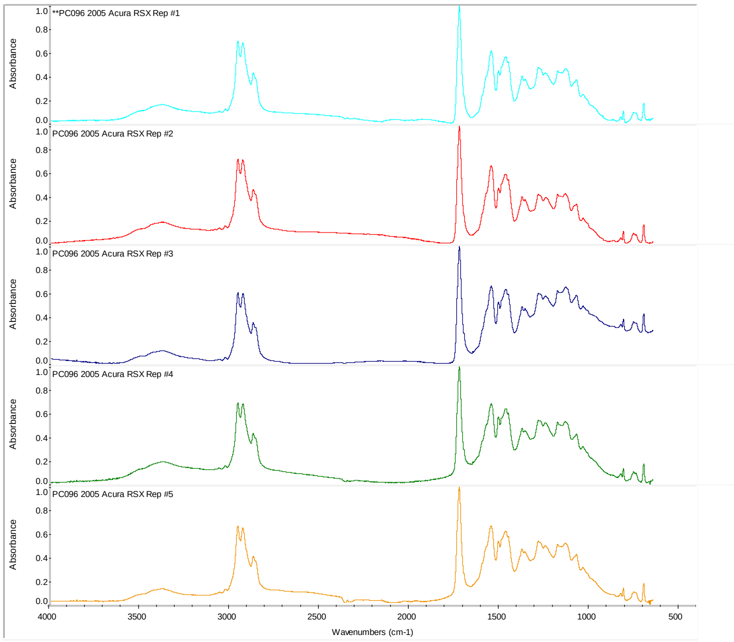
Title: PC096 2005 Acura RSX

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



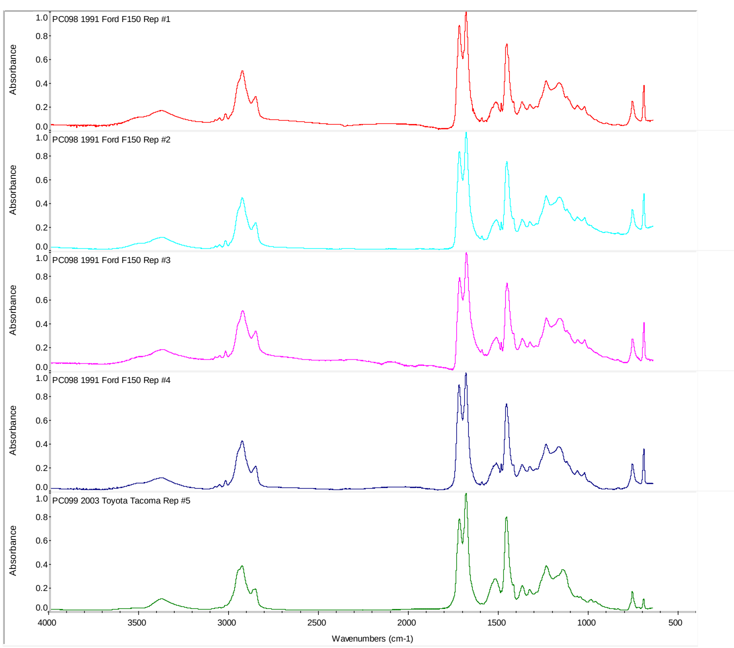
Title: PC098 1991 Ford F150

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



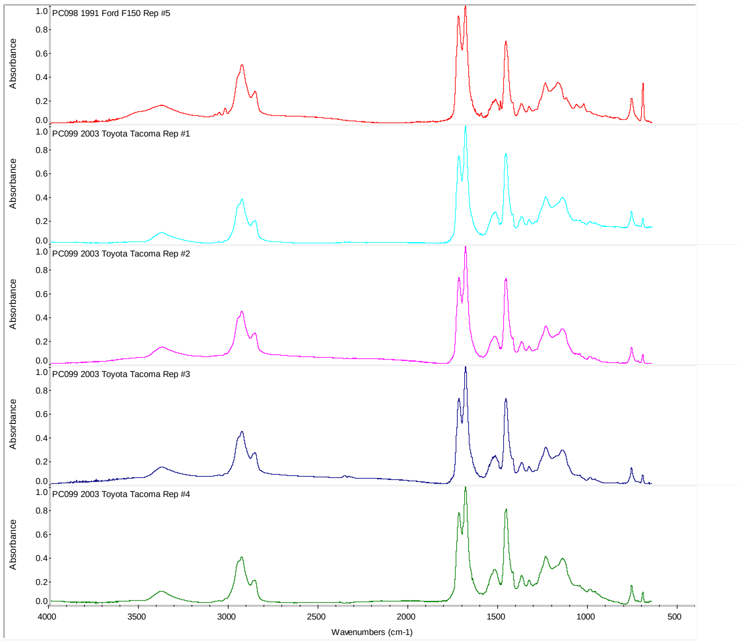
Title: PC098 1991 Ford F150

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



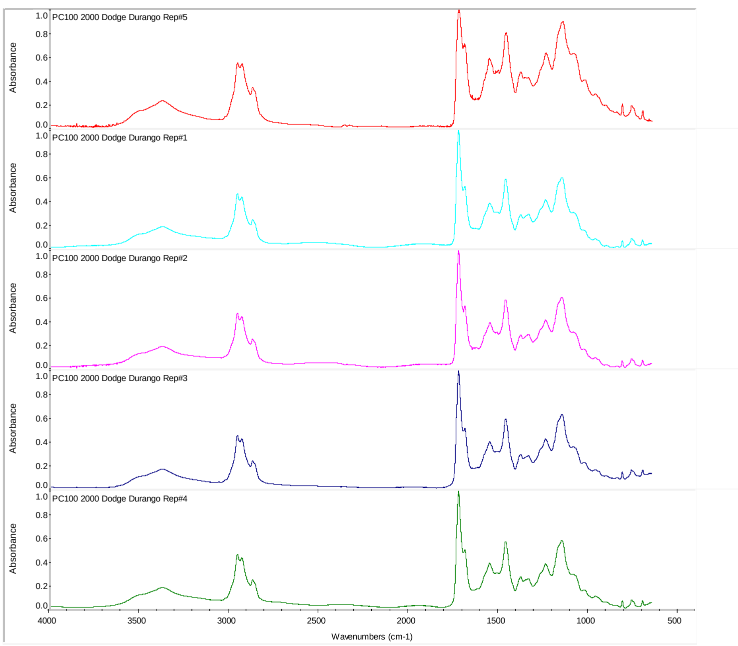
Title: PC100 2000 Dodge Durango

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



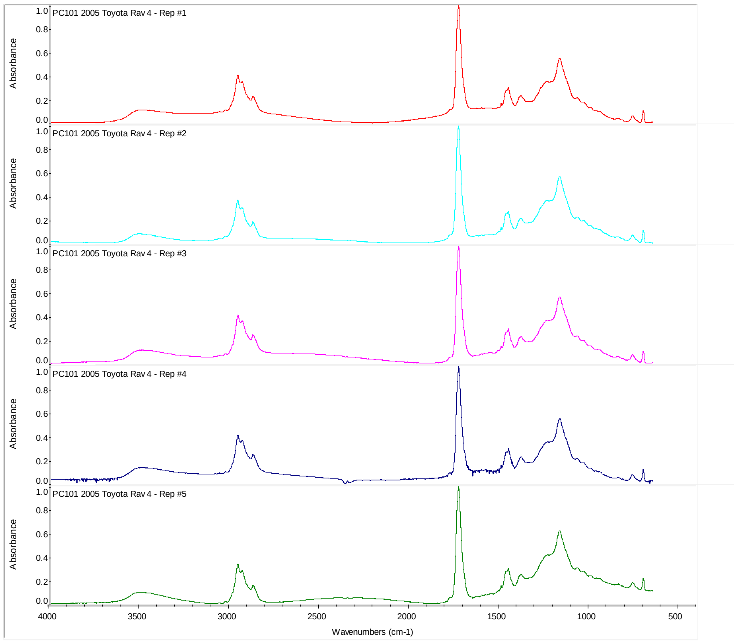
Title: PC101 2005 Toyota Rav 4

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



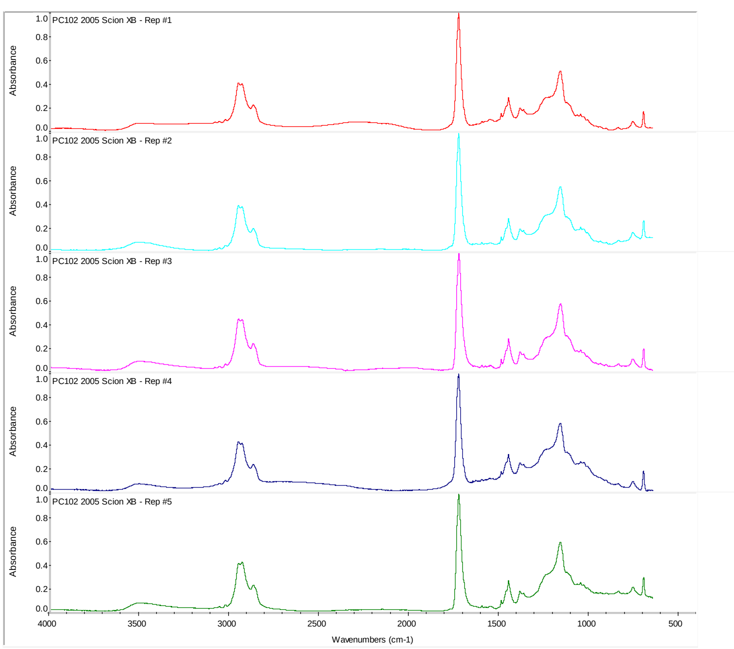
Title: PC102 2005 Scion XB

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



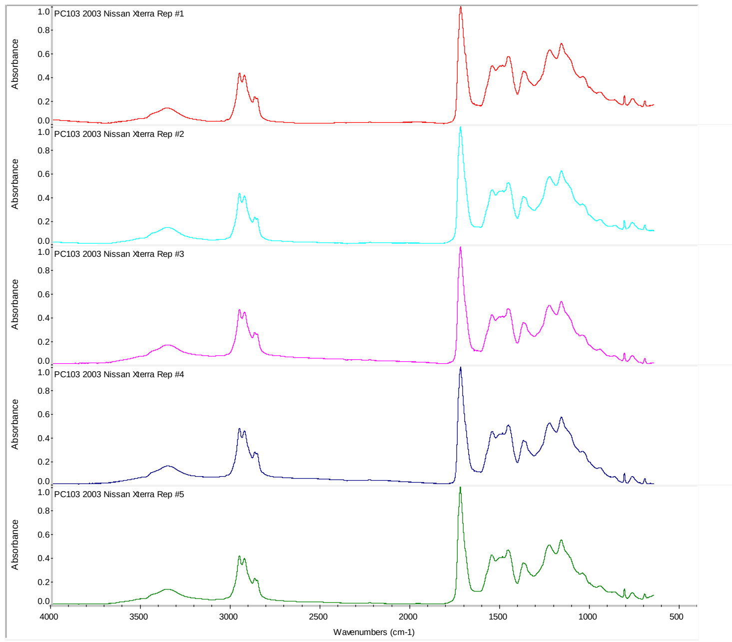
Title: PC103 2003 Nissan Xterra

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



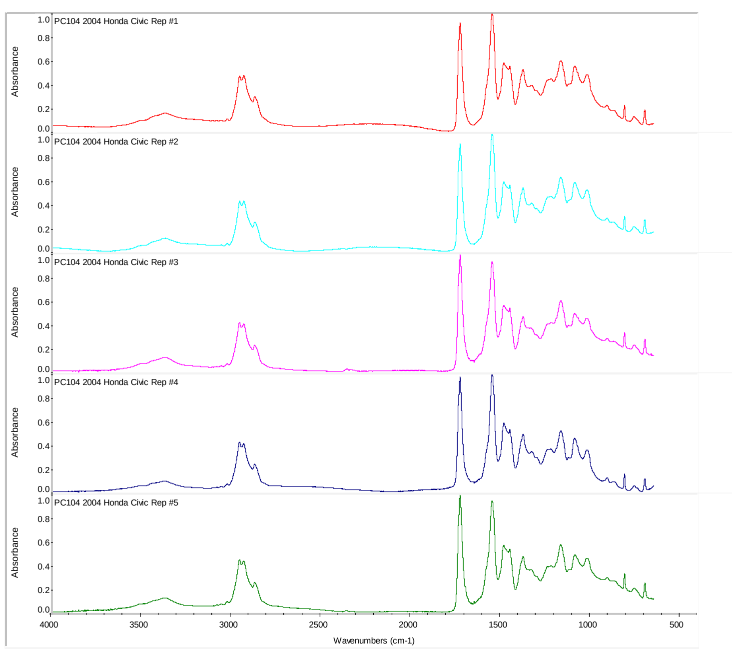
Title: PC104 2004 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



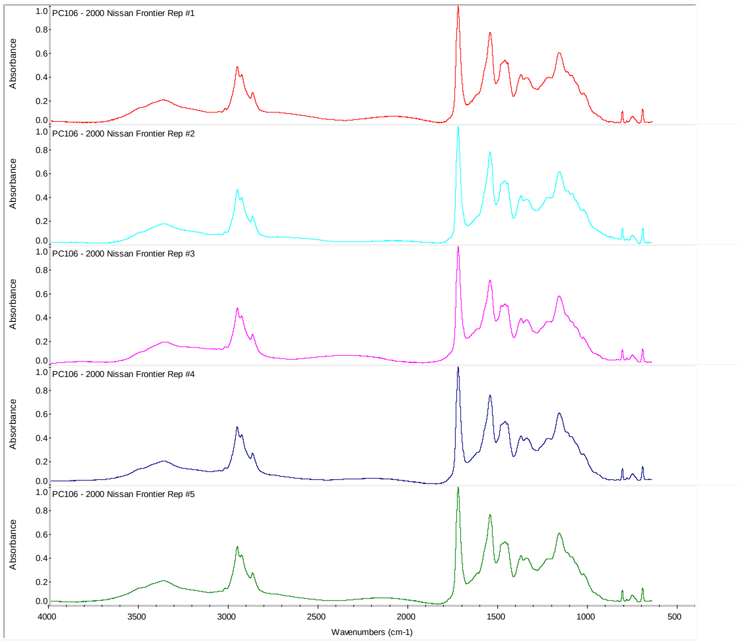
Title: PC106 - 2000 Nissan Frontier

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



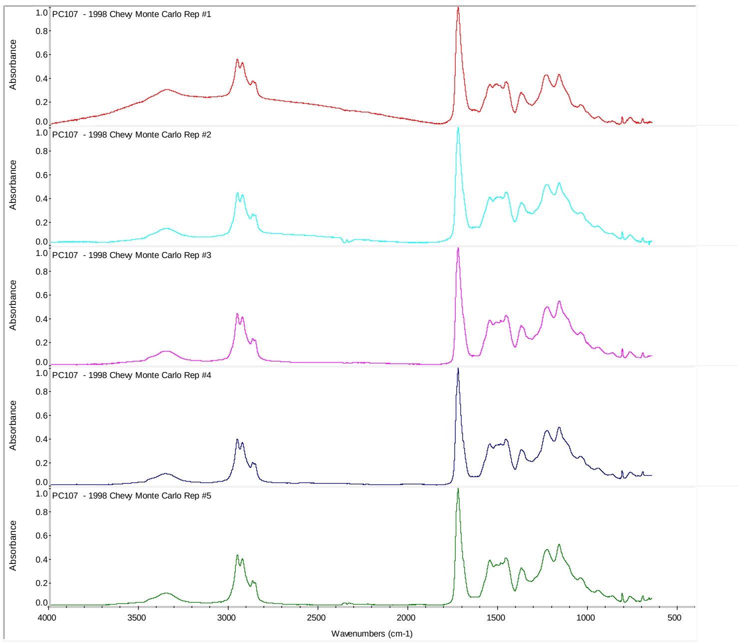
Title: PC107 - 1998 Chevy Monte Carlo

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



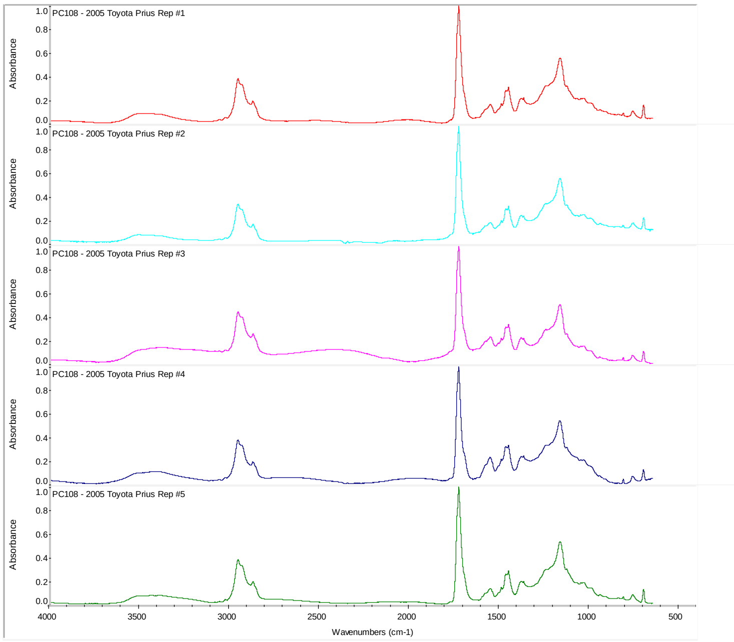
Title: PC108 - 2005 Toyota Prius

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



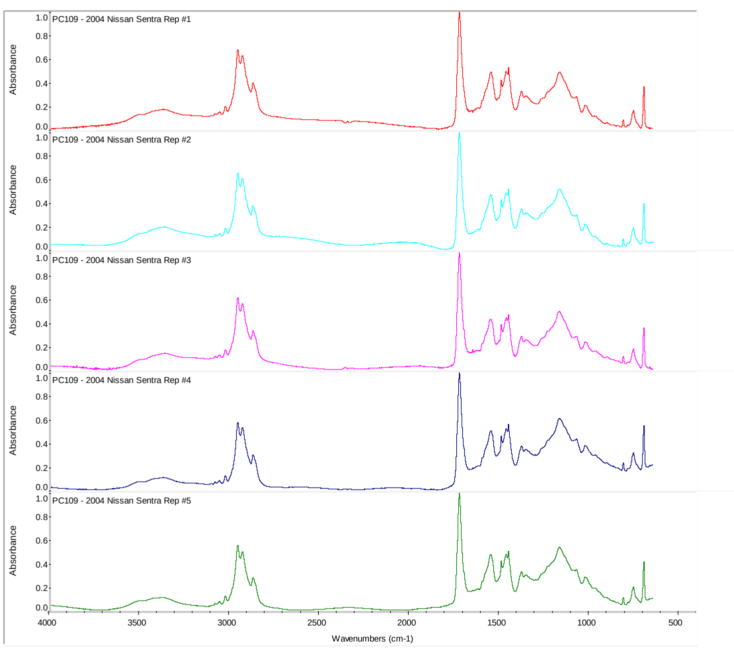
Title: PC109 - 2004 Nissan Sentra

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



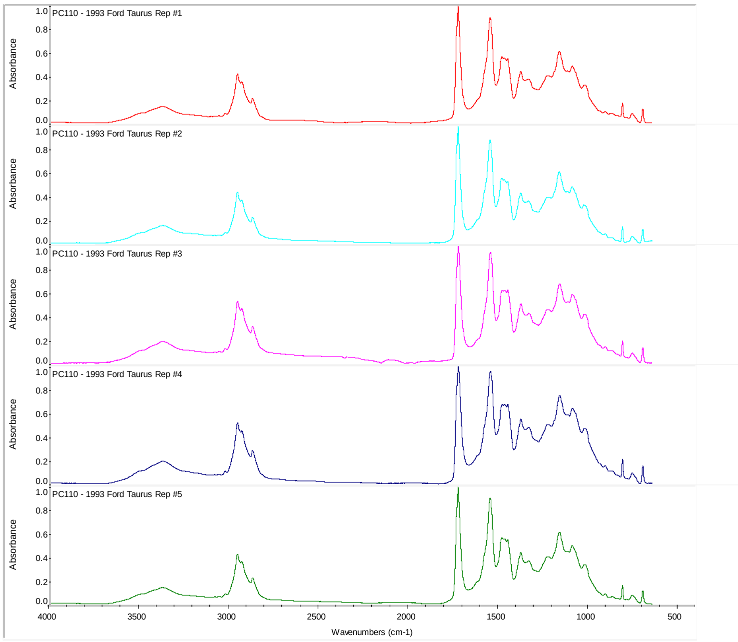
Title: PC110 - 1993 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



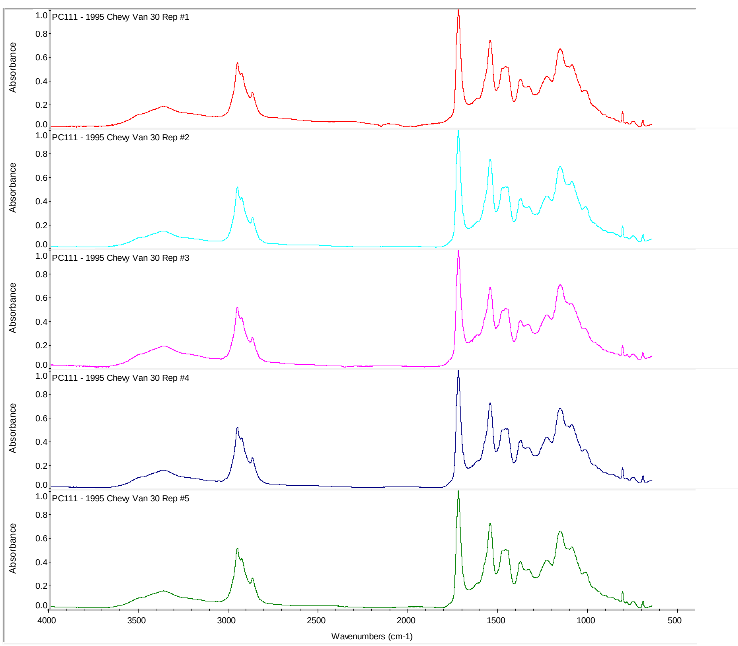
Title: PC111 - 1995 Chevy Van 30

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



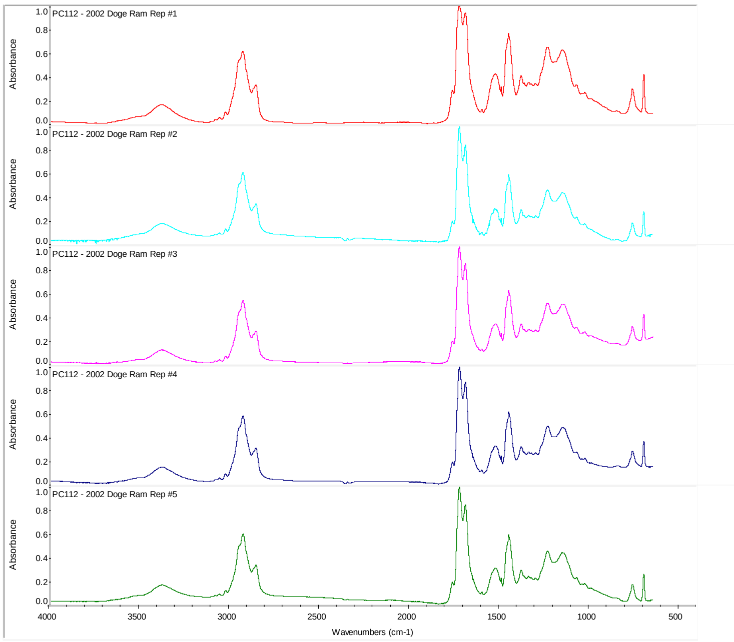
Title: PC112 - 2002 Doge Ram

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



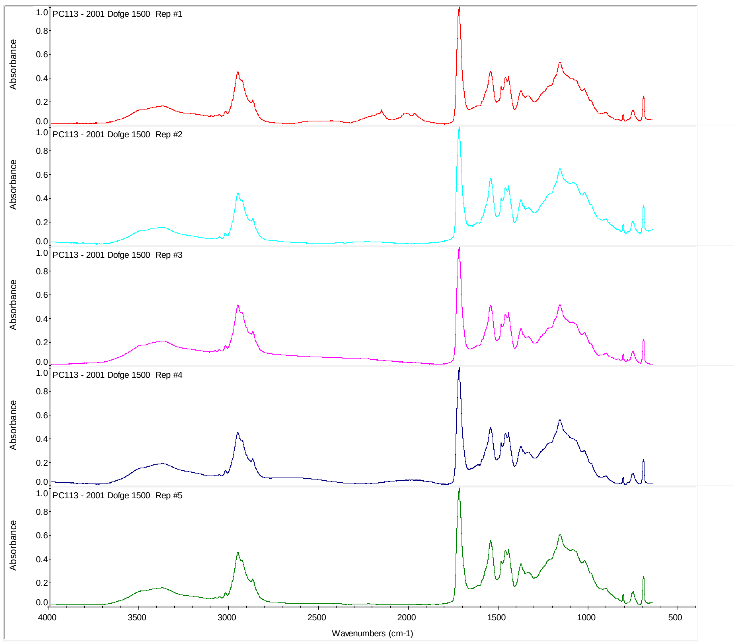
Title: PC113 - 2001 Dofge 1500

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



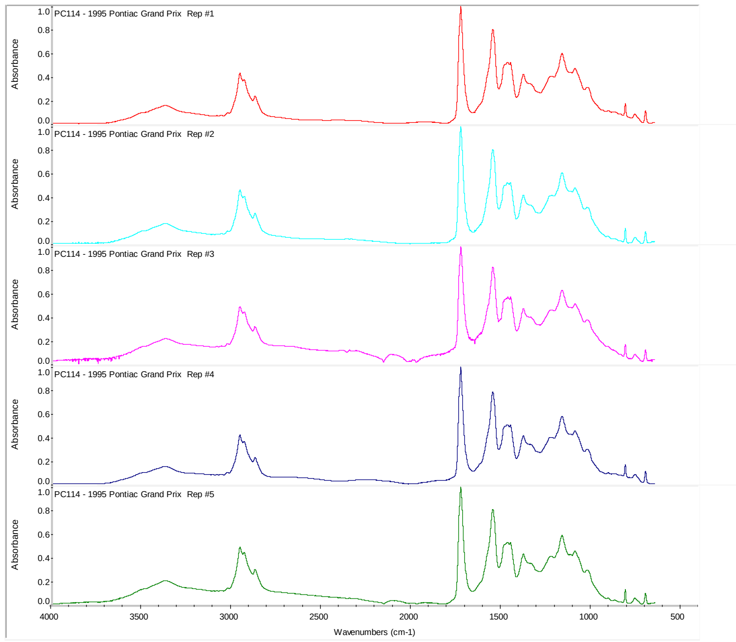
Title: PC114 - 1995 Pontiac Grand Prix

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



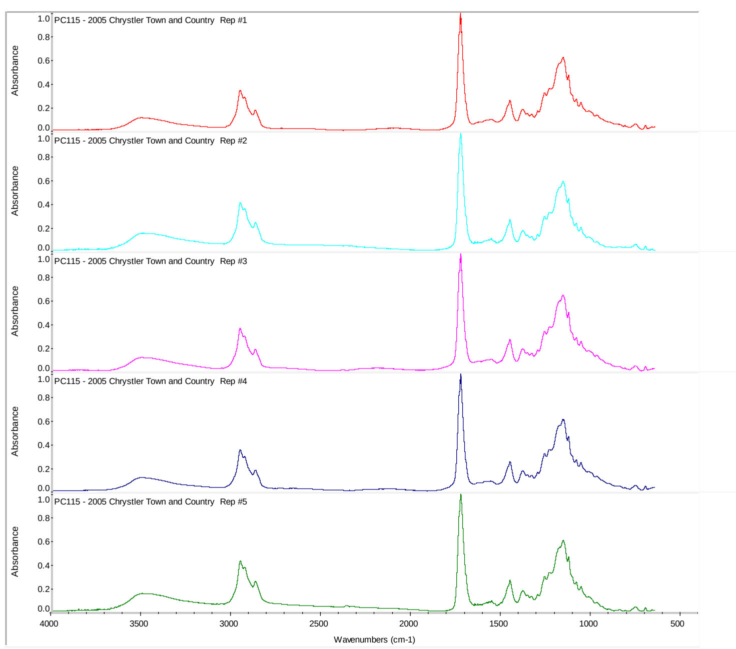
Title: PC115 - 2005 Chrystler Town and Country

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



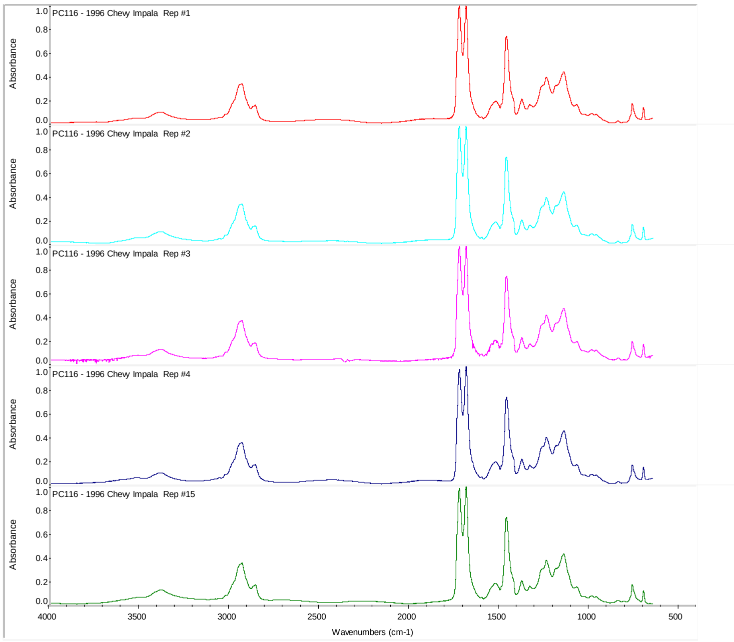
Title: PC116 - 1996 Chevy Impala

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



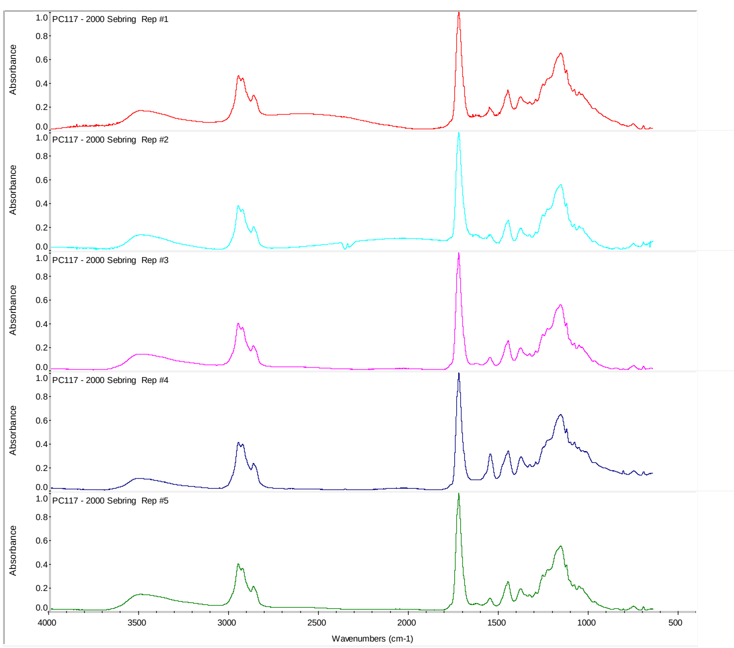
Title: PC117 - 2000 Sebring

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



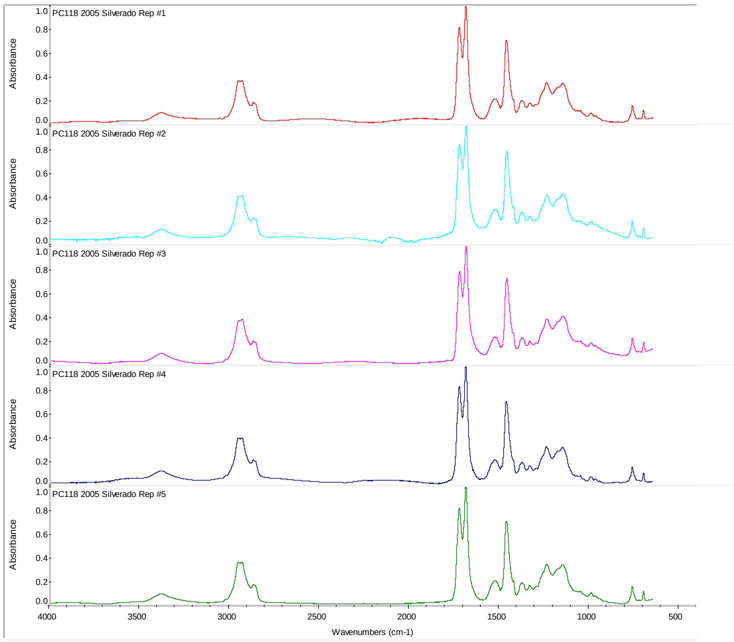
Title: PC118 2005 Silverado

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



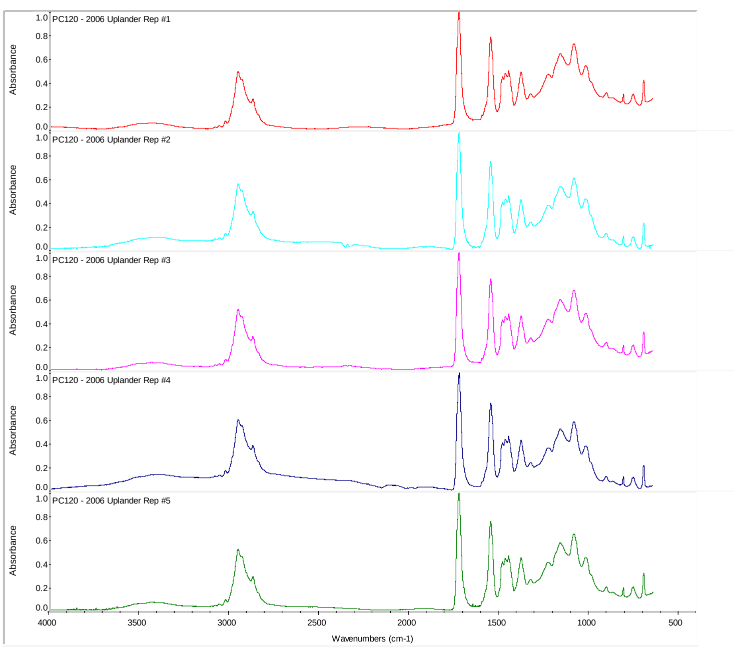
Title: PC120 - 2006 Uplander

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



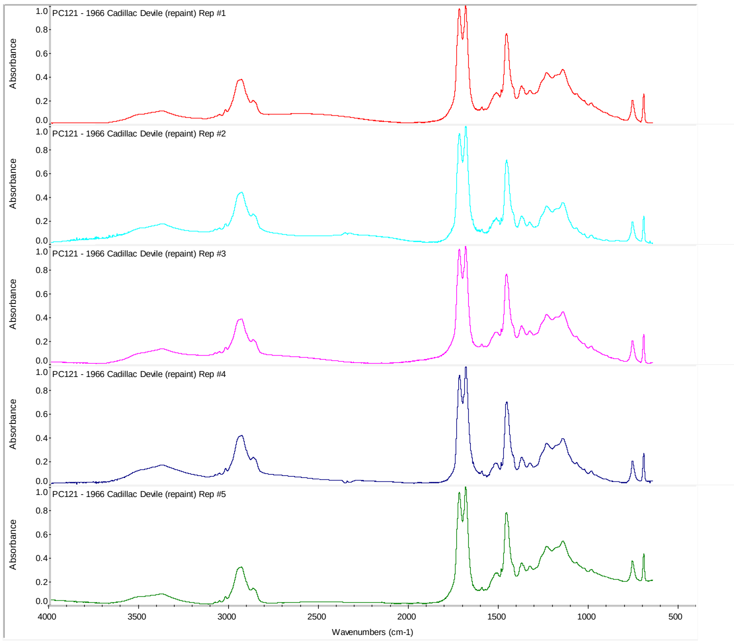
Title: PC121 - 1966 Cadillac Devile (repaint)

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



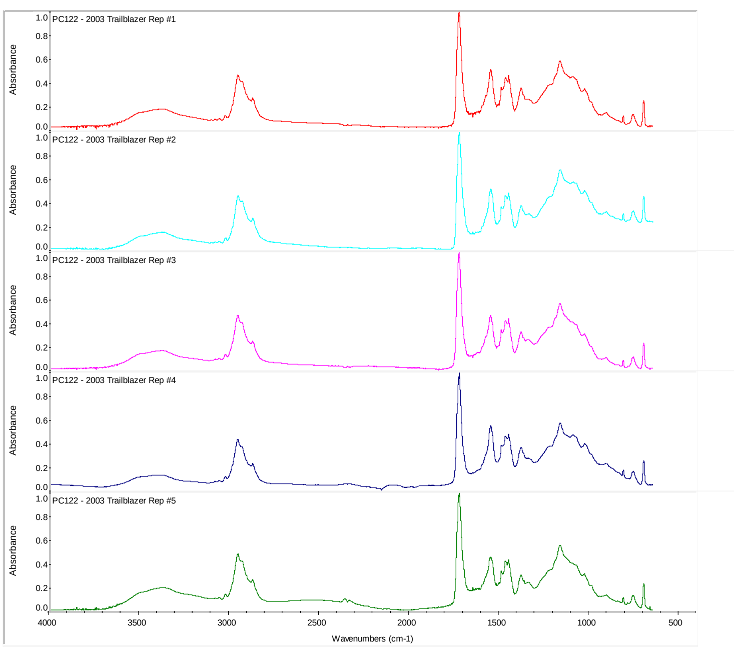
Title: PC122 - 2003 Trailblazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



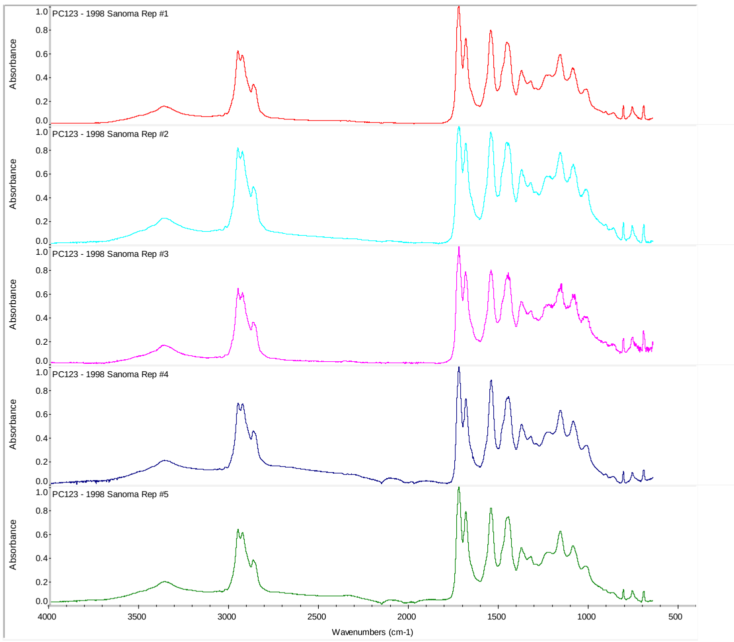
Title: PC123 - 1998 Sanoma

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



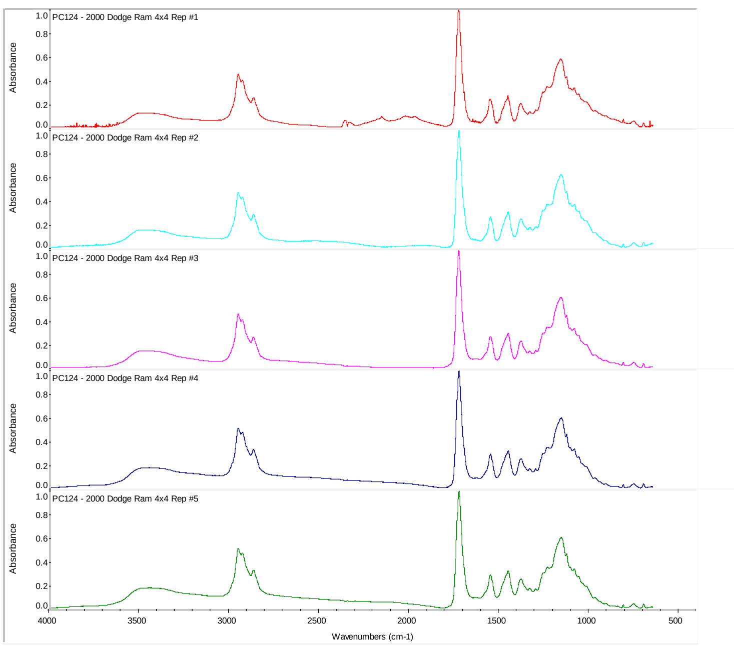
Title: PC124 - 2000 Dodge Ram 4x4

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



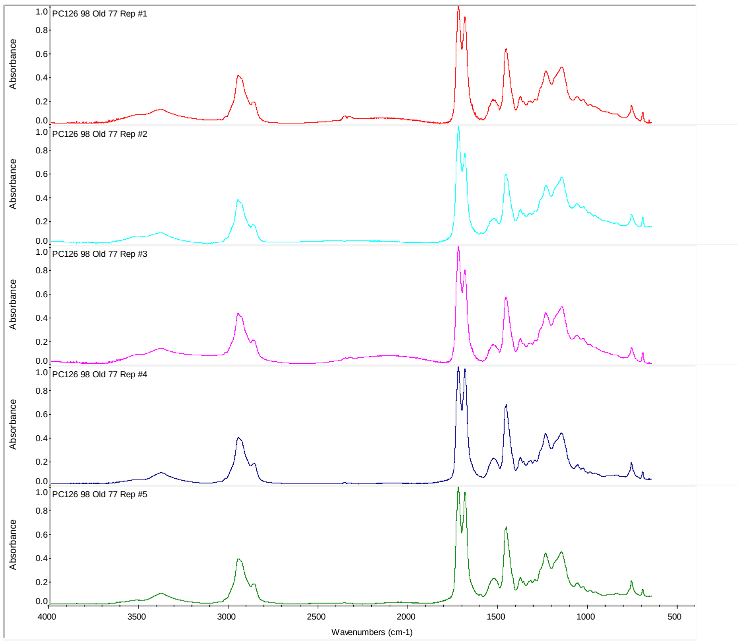
Title: PC126 98 Old 77

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



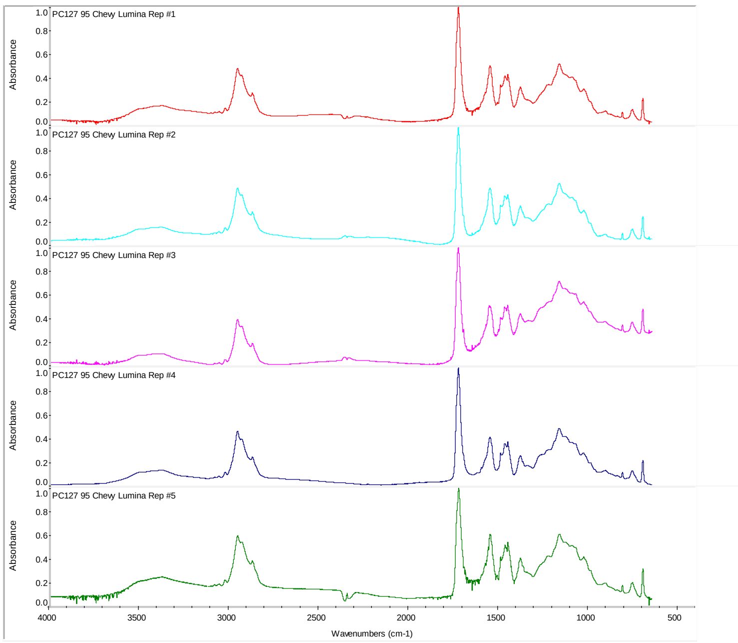
Title: PC127 95 Chevy Lumina

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



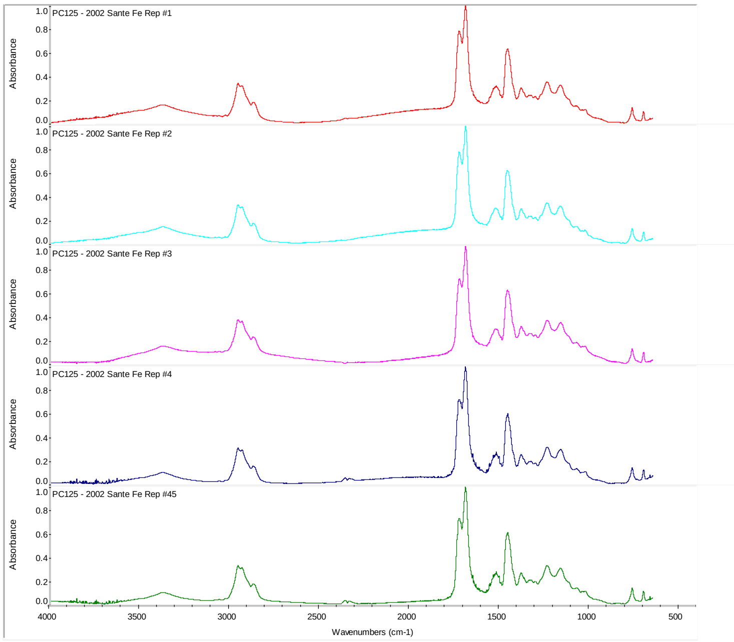
Title: PC125 - 2002 Sante Fe

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



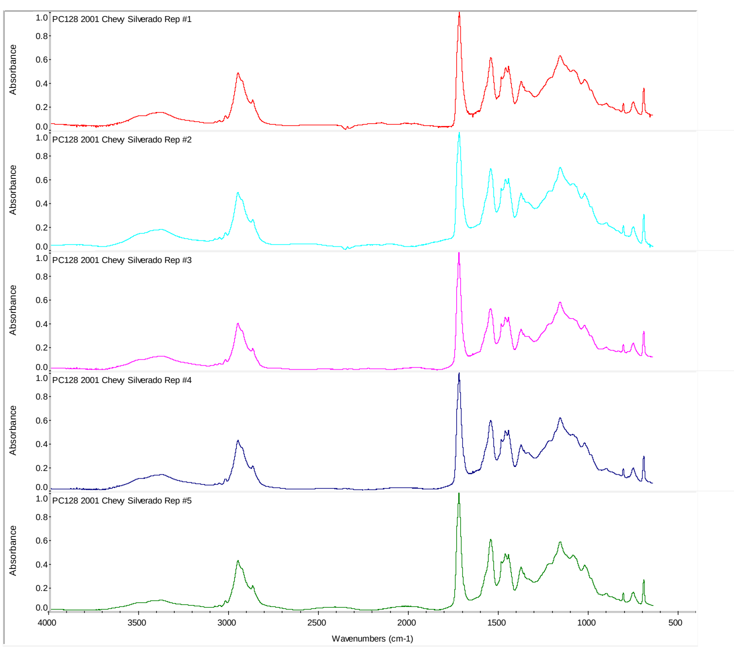
Title: PC128 2001 Chevy Silverado

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



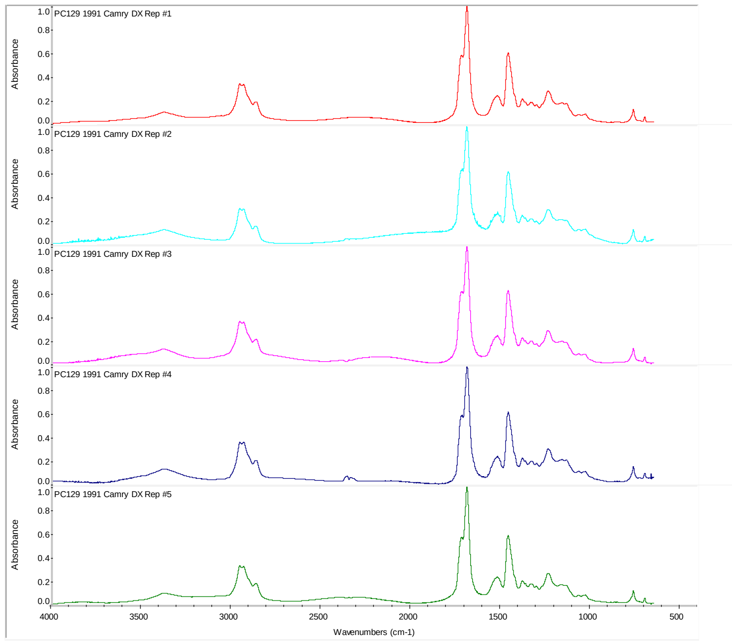
Title: PC129 1991 Camry DX

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



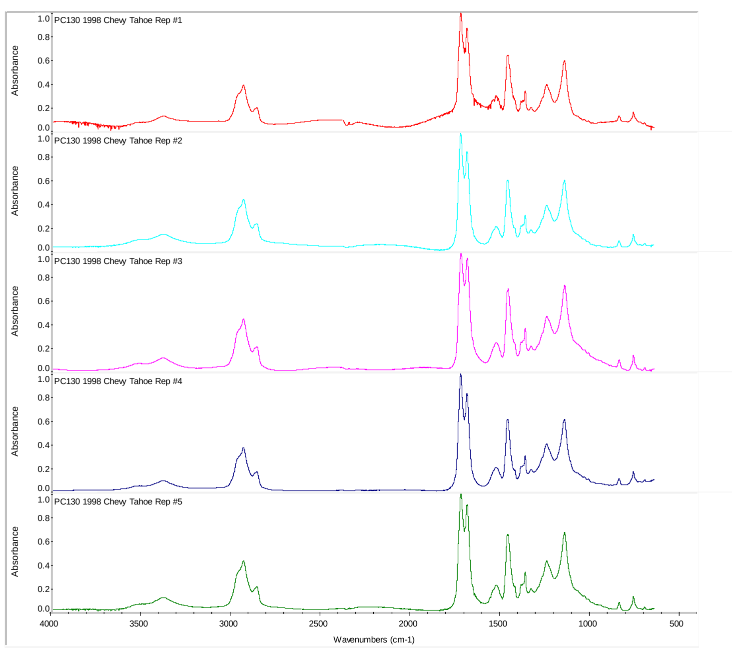
Title: PC130 1998 Chevy Tahoe

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



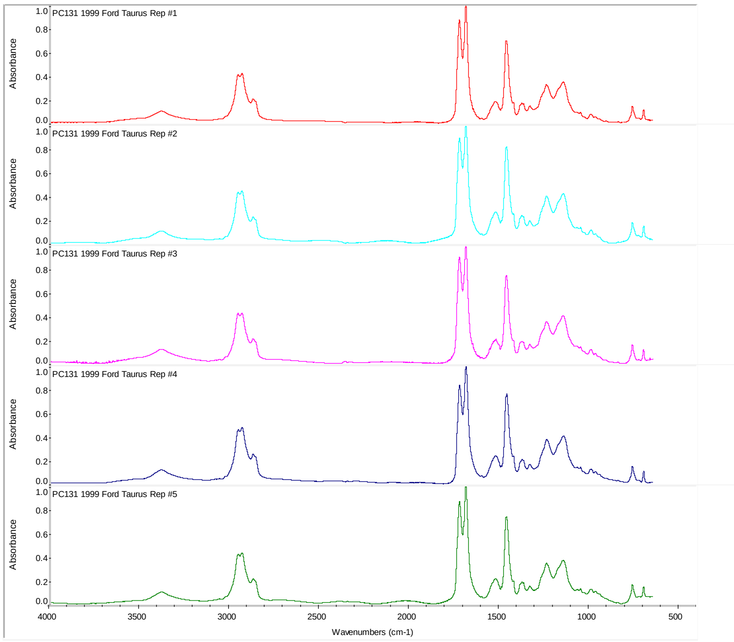
Title: PC131 1999 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



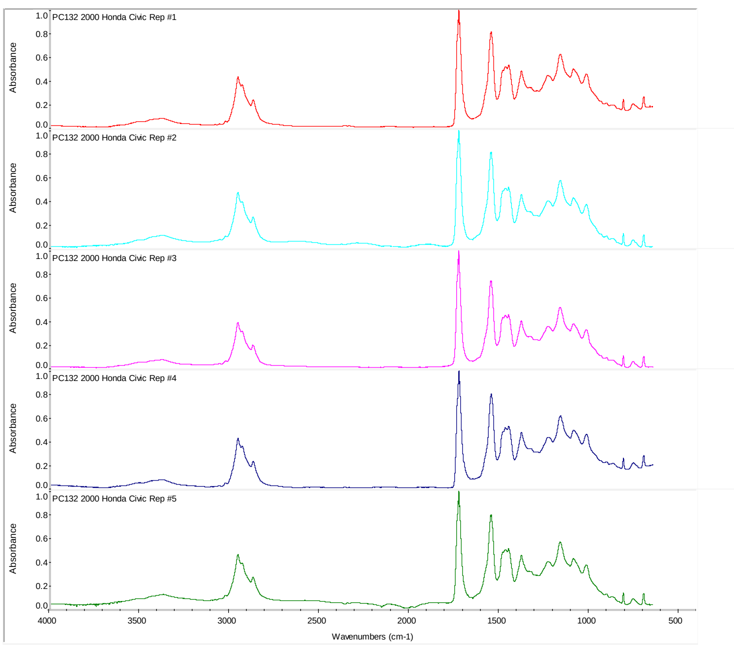
Title: PC132 2000 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



Title: PC133 2004 Chrysler Town and Country

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:

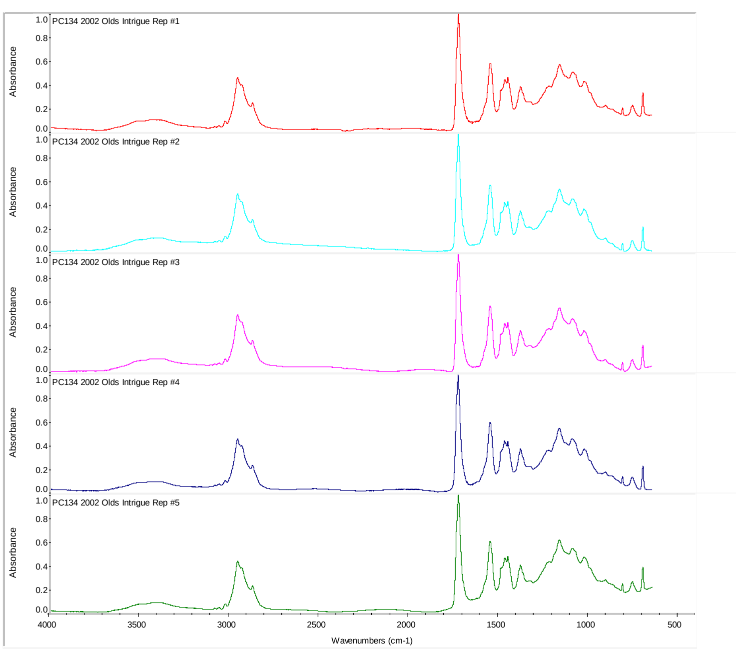
Title: PC134 2002 Olds Intrigue

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



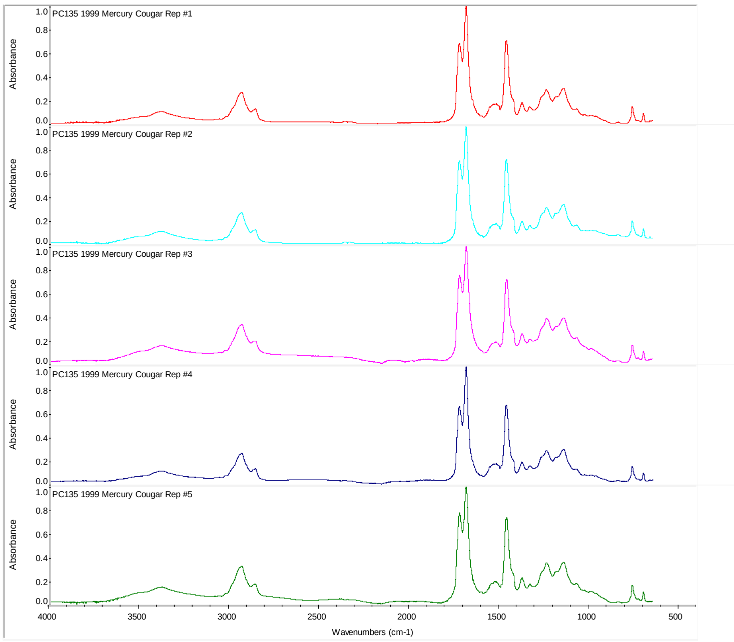
Title: PC135 1999 Mercury Cougar

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



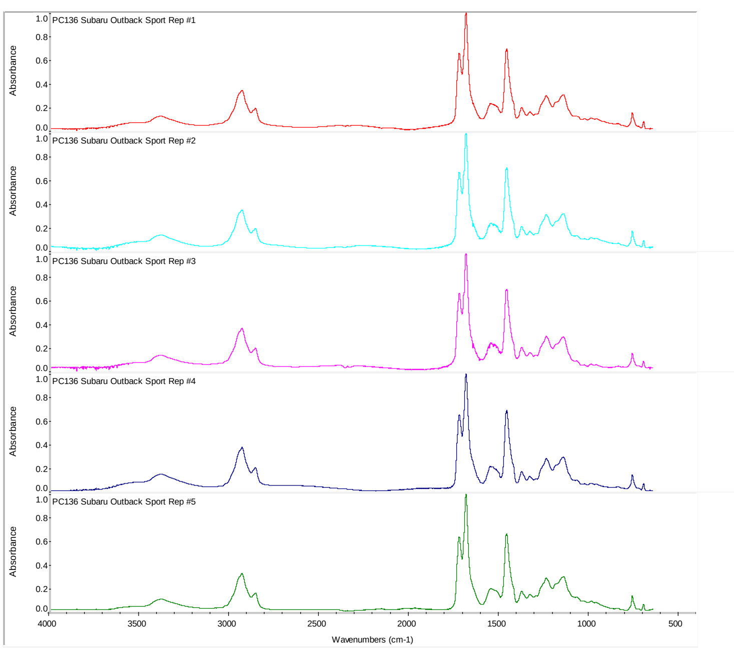
Title: PC136 Subaru Outback Sport

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



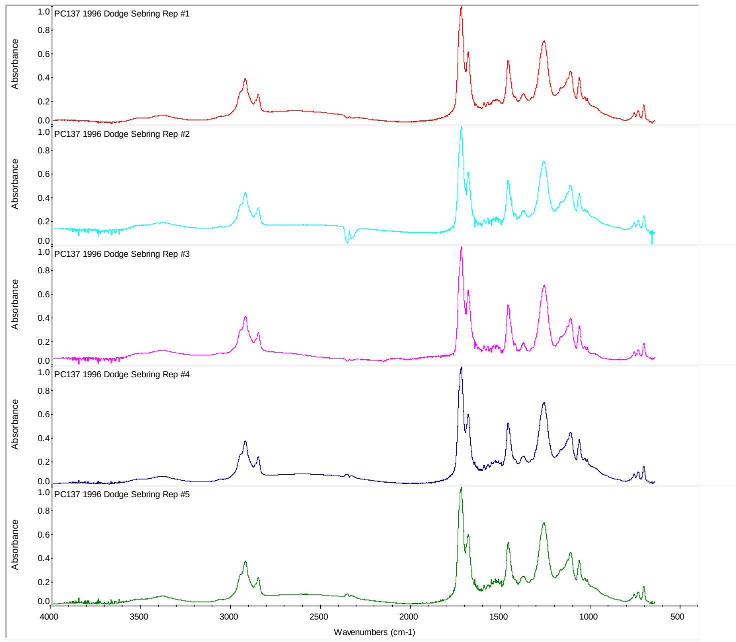
Title: PC137 1996 Dodge Sebring

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Sample is blue tinted with dark specs in the samples.
Very thin clear coat.



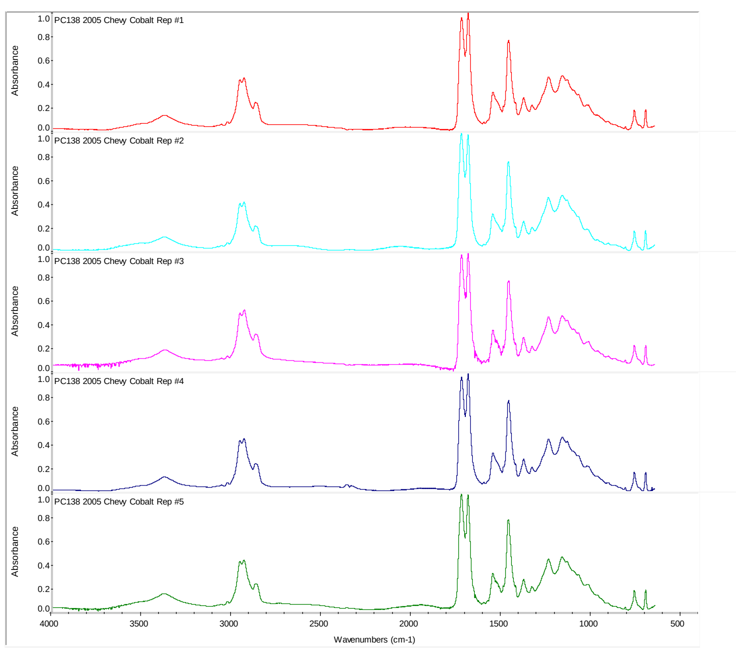
Title: PC138 2005 Chevy Cobalt

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



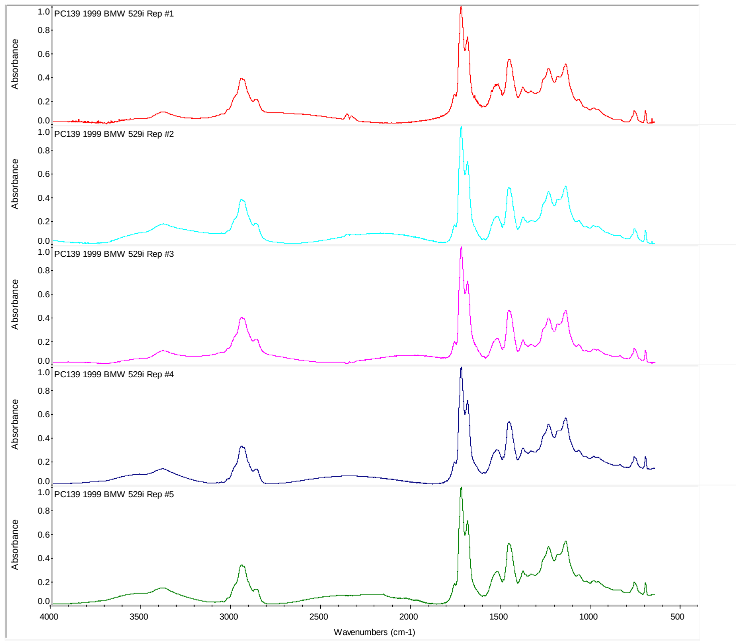
Title: PC139 1999 BMW 529i

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



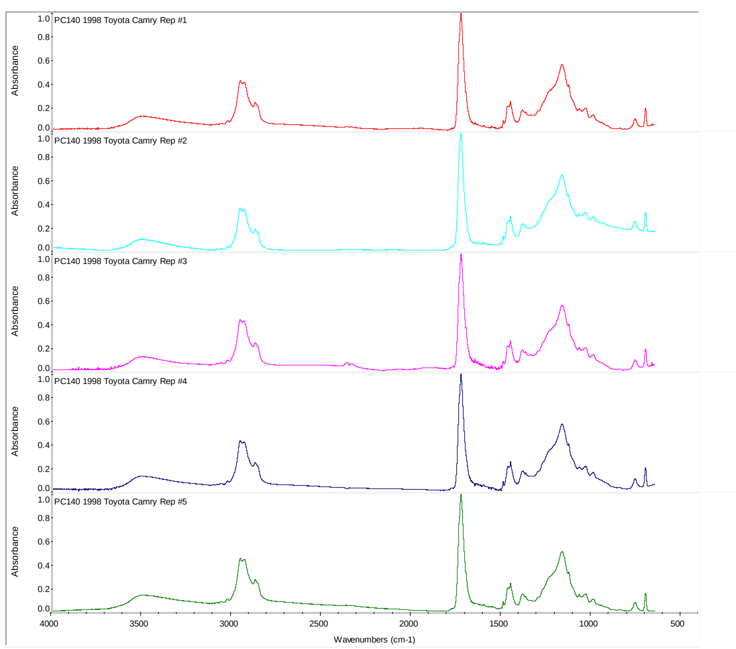
Title: PC140 1998 Toyota Camry

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



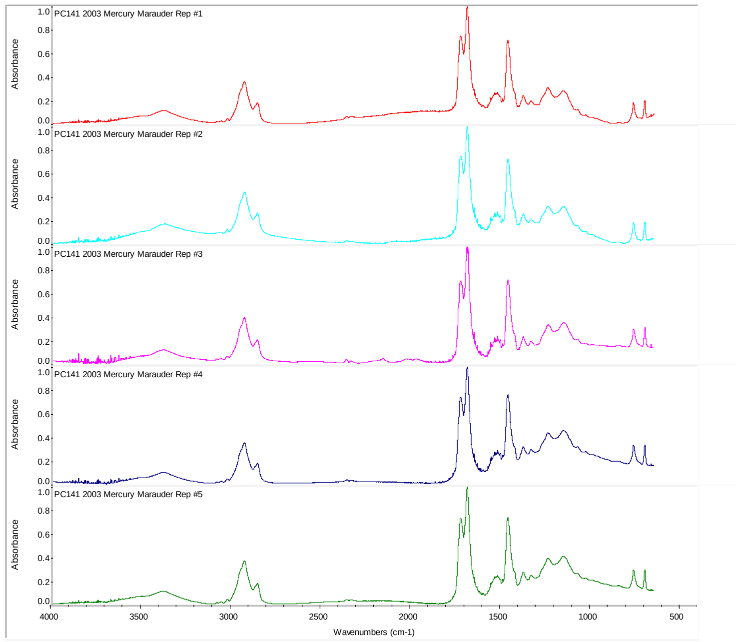
Title: PC141 2003 Mercury Marauder

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



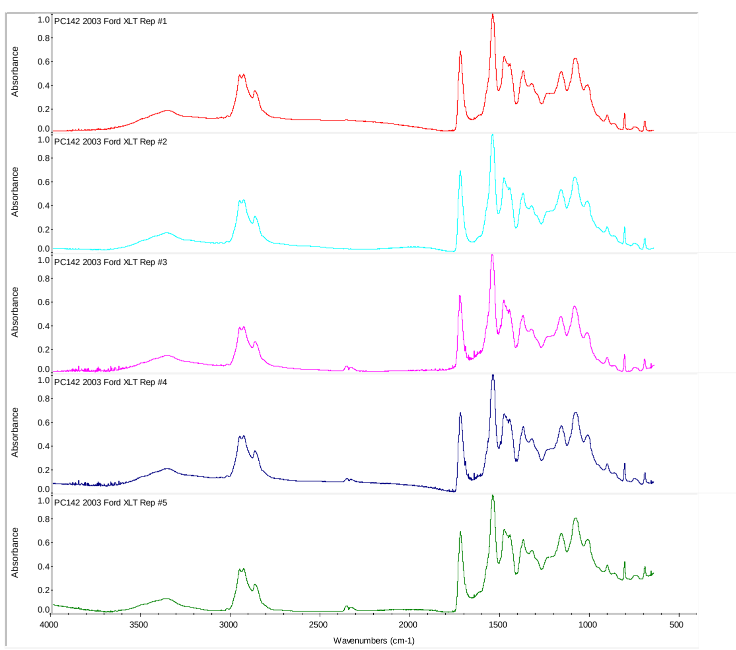
Title: PC142 2003 Ford XLT

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



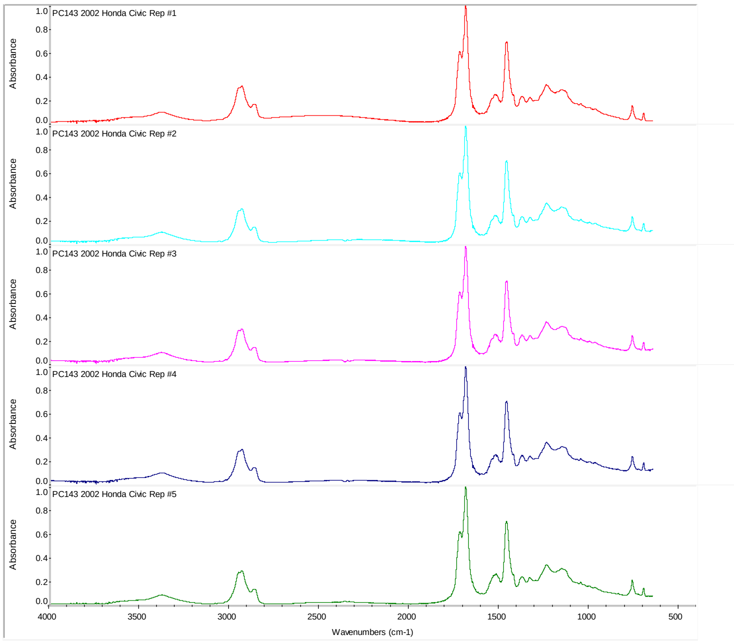
Title: PC143 2002 Honda Civic

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



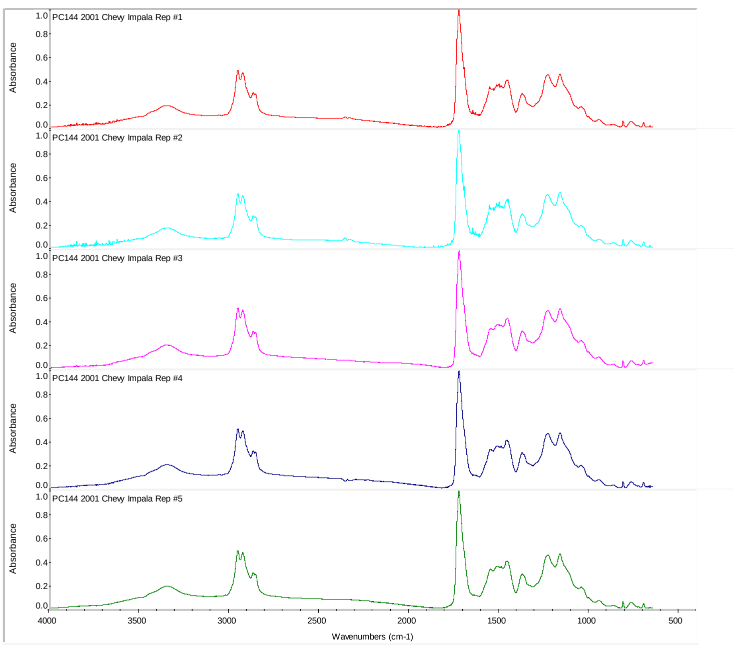
Title: PC144 2001 Chevy Impala

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



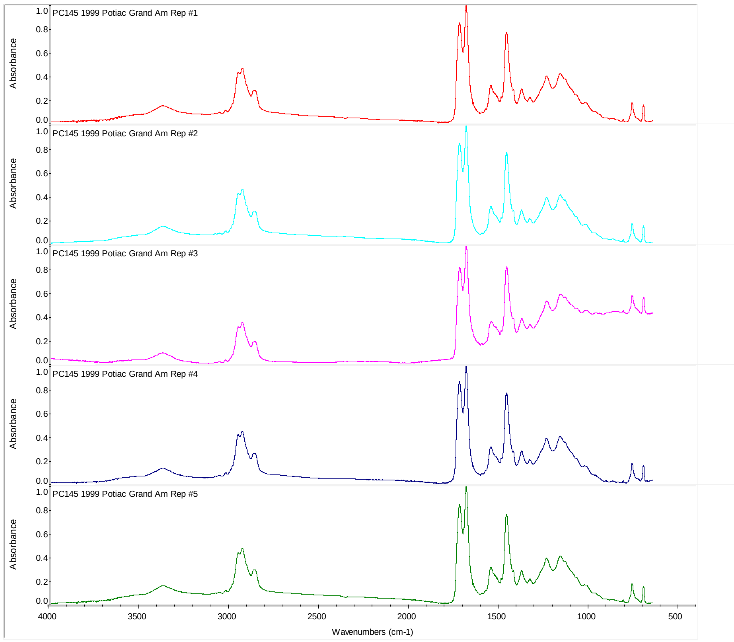
Title: PC145 1999 Potiac Grand Am

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



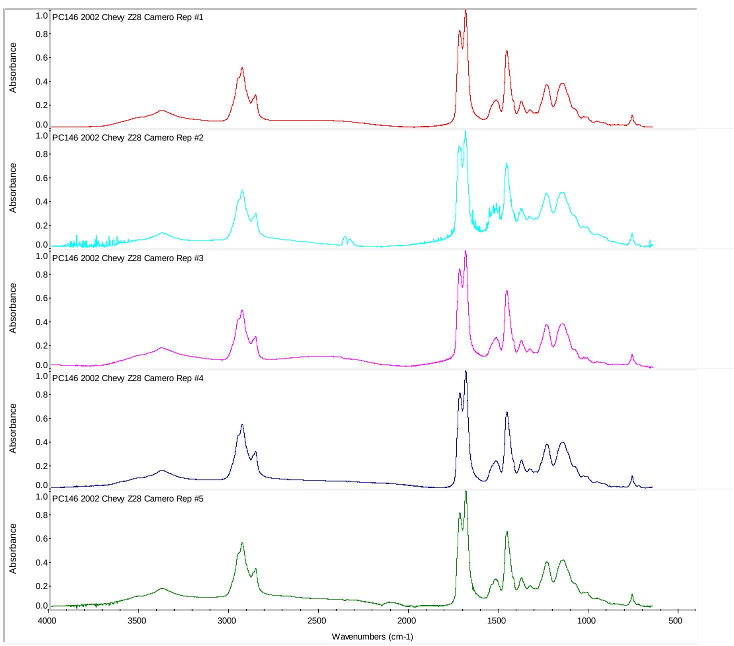
Title: PC146 2002 Chevy Z28 Camero

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



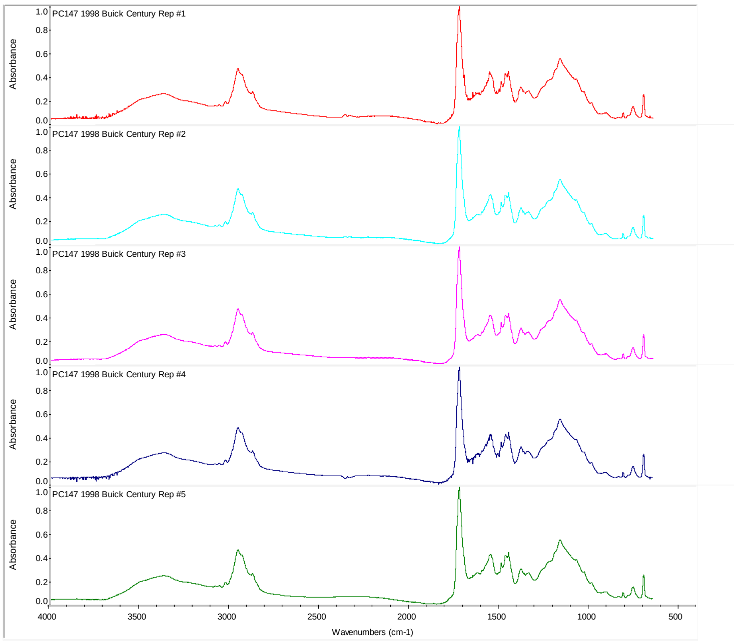
Title: PC147 1998 Buick Century

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



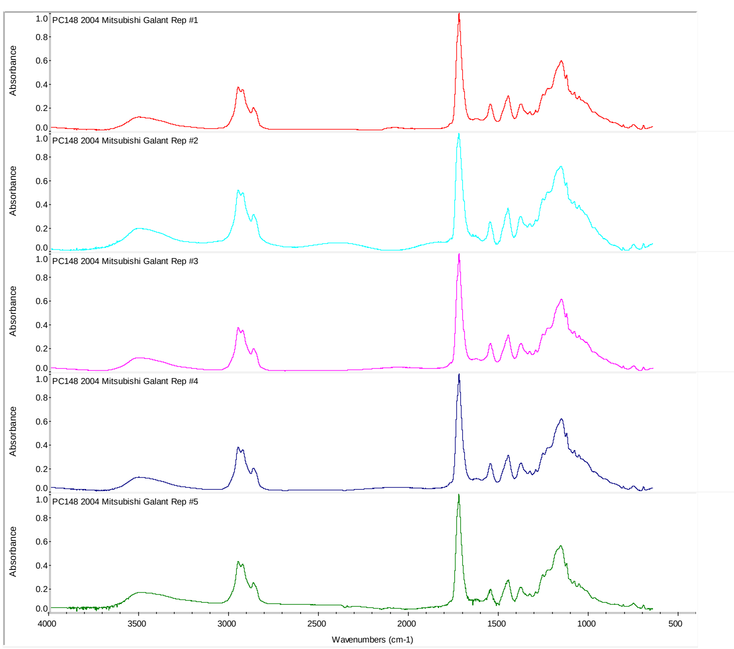
Title: PC148 2004 Mitsubishi Galant

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



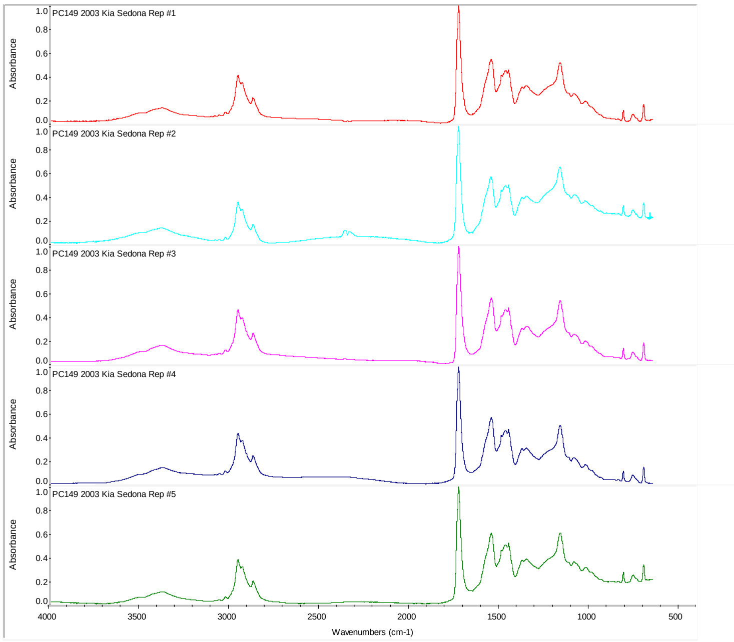
Title: PC149 2003 Kia Sedona

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



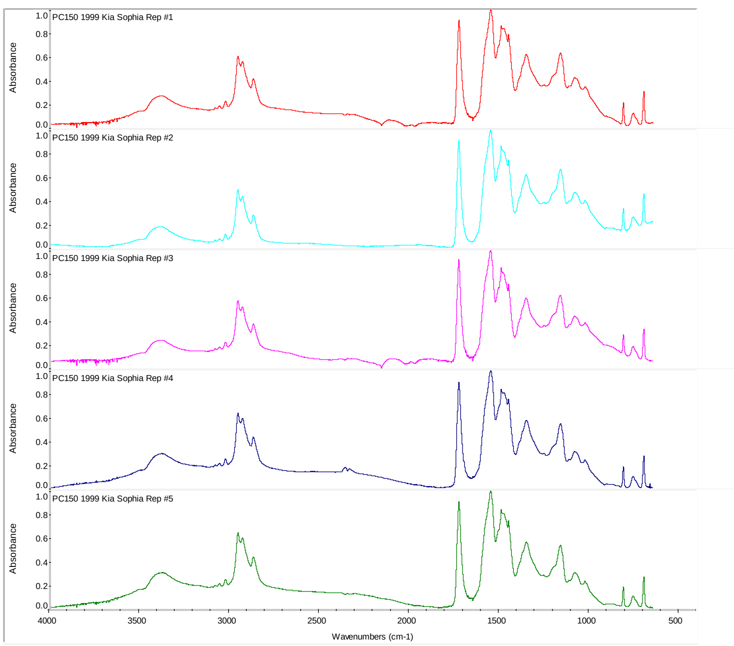
Title: PC150 1999 Kia Sophia

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



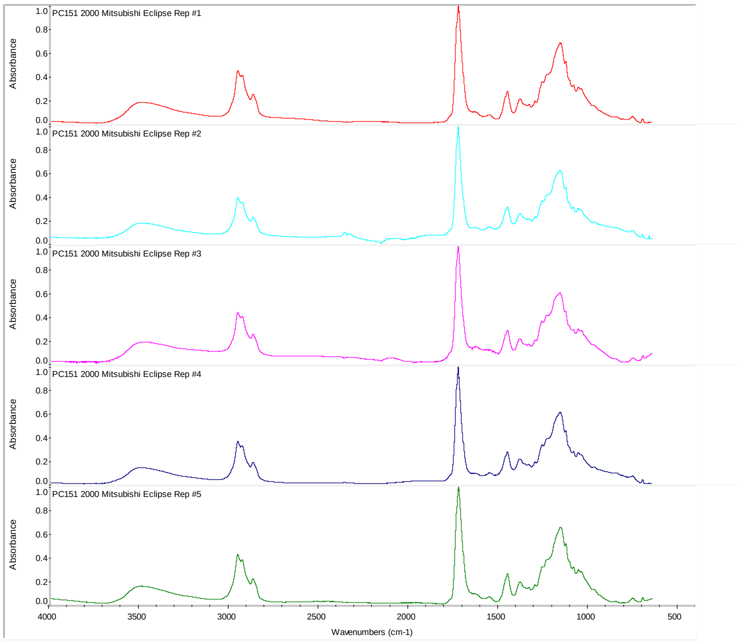
Title: PC151 2000 Mitsubishi Eclipse

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



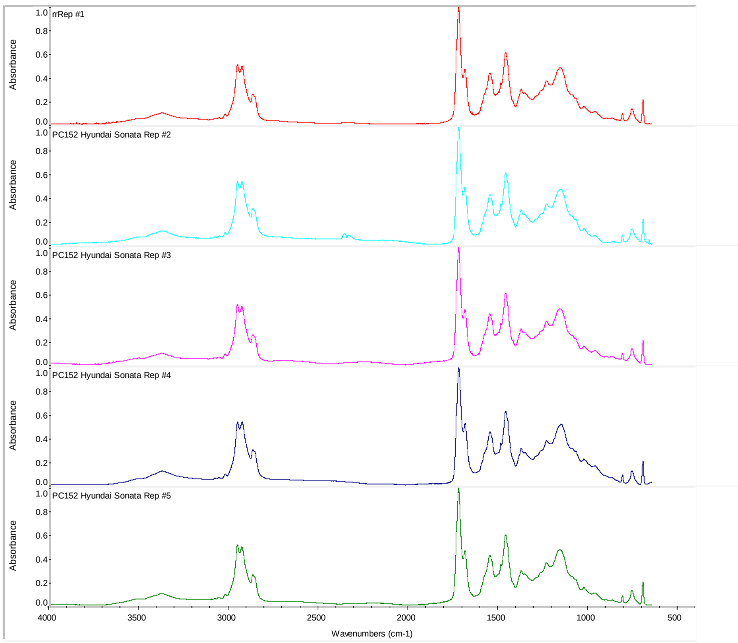
Title: PC152 Hyundai Sonata

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



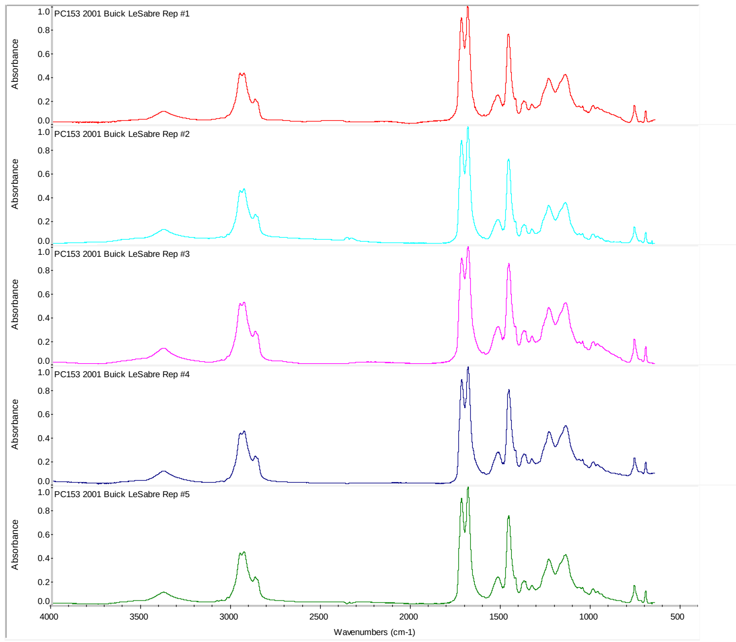
Title: PC153 2001 Buick LeSabre

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



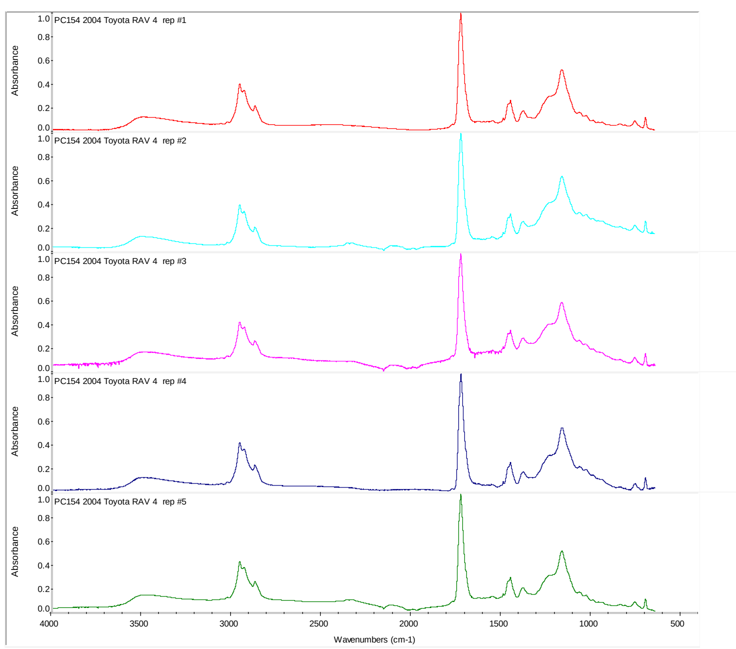
Title: PC154 2004 Toyota RAV 4

Analyst: James D. Osborne

Number of sample scans: 129
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



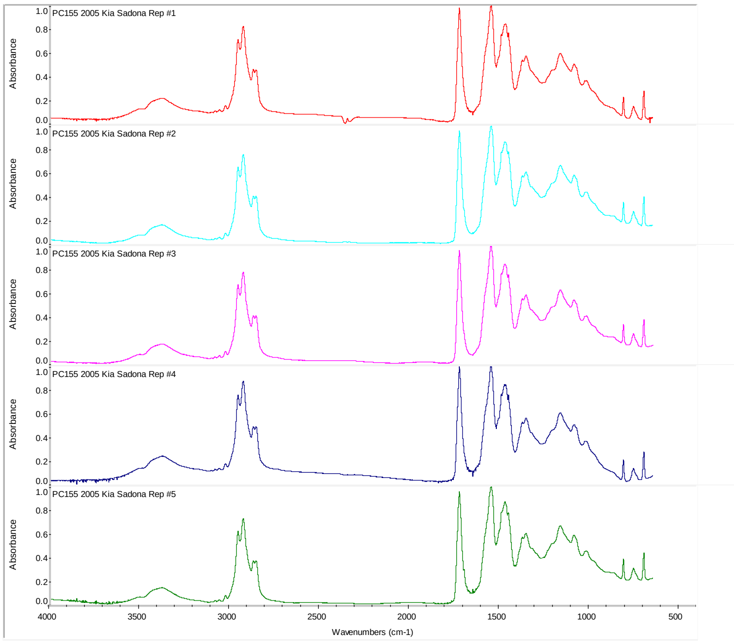
Title: PC155 2005 Kia Sadona

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



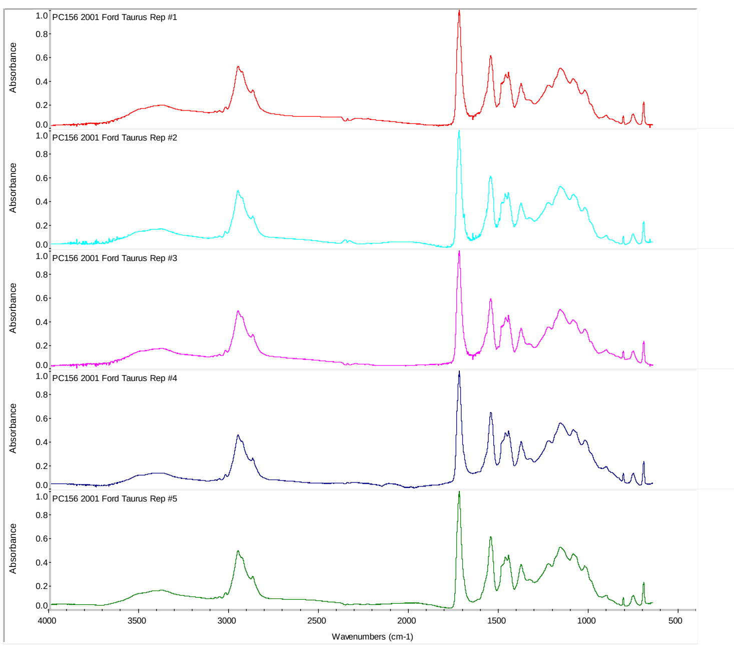
Title: PC156 2001 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



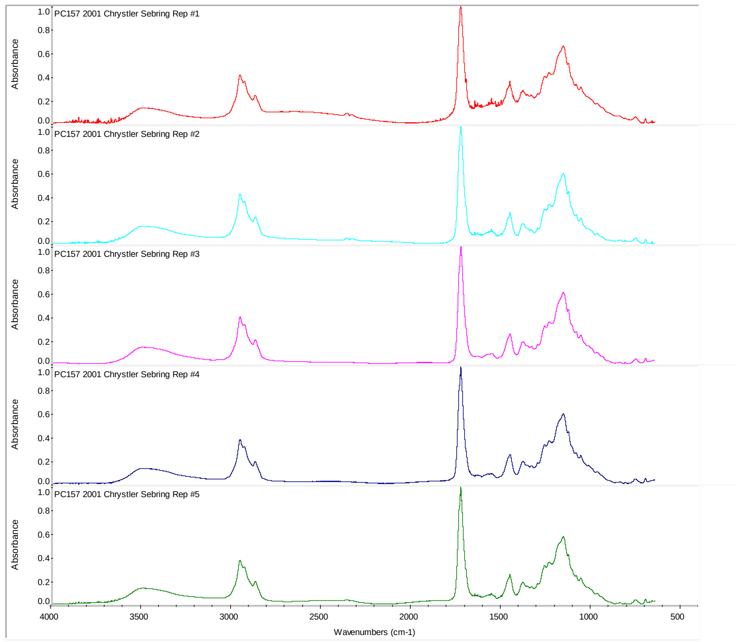
Title: PC157 2001 Chrystler Sebring

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



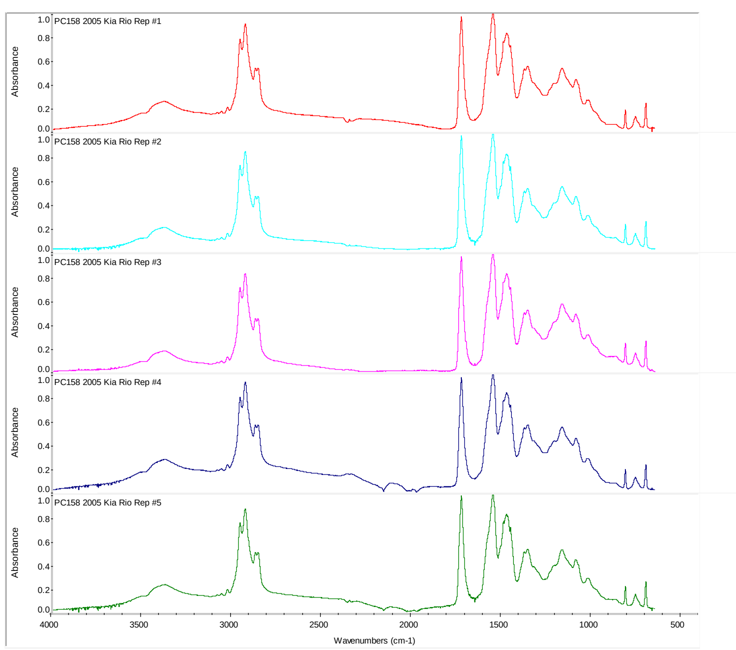
Title: PC158 2005 Kia Rio

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



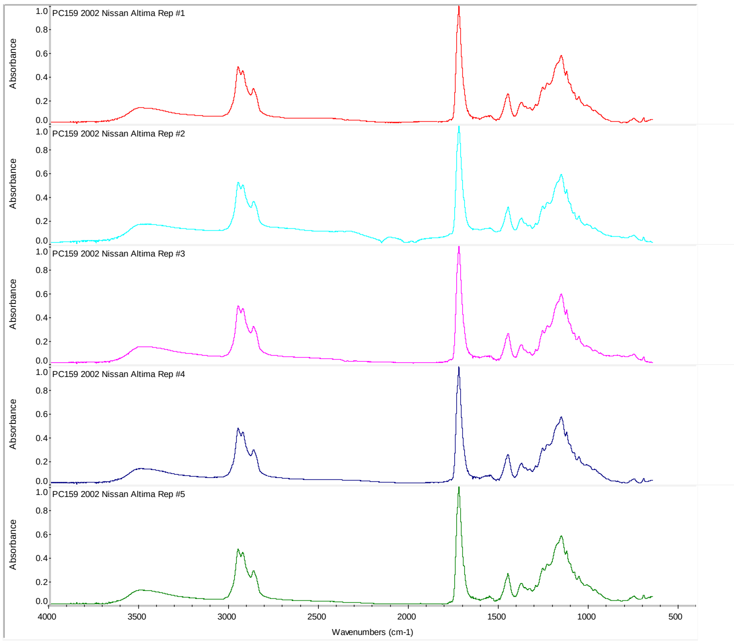
Title: PC159 2002 Nissan Altima

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



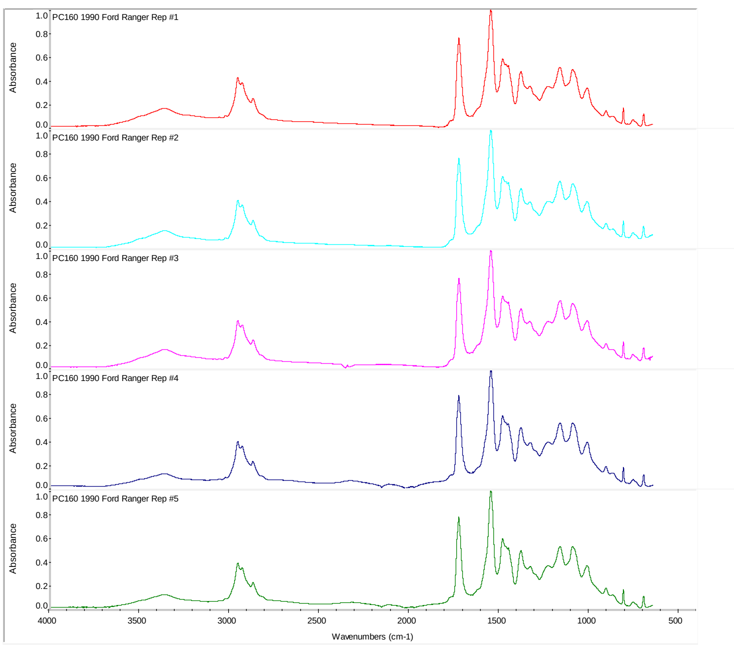
Title: PC160 1990 Ford Ranger

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



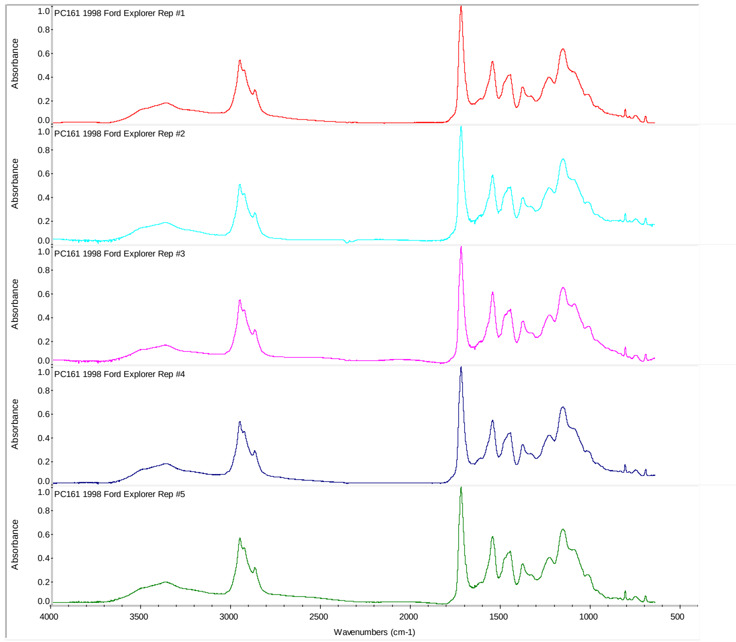
Title: PC161 1998 Ford Explorer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



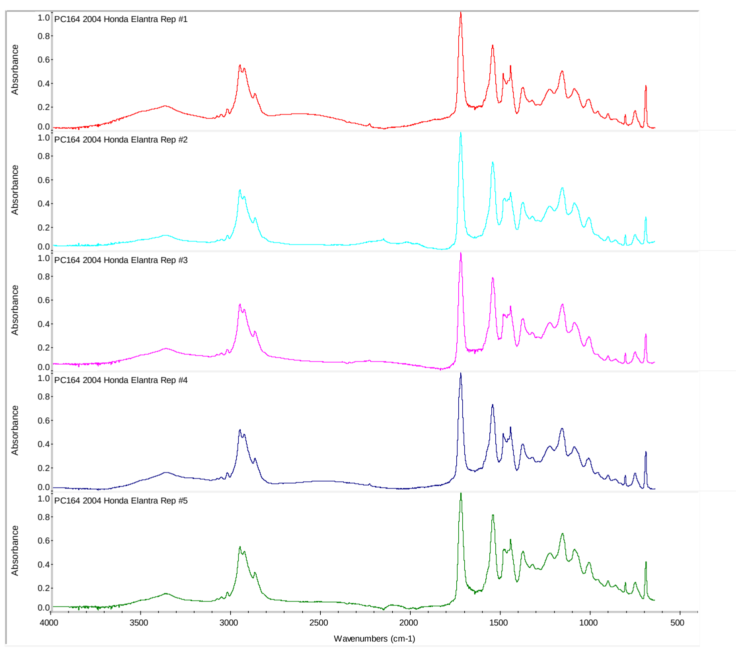
Title: PC164 2004 Honda Elantra

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



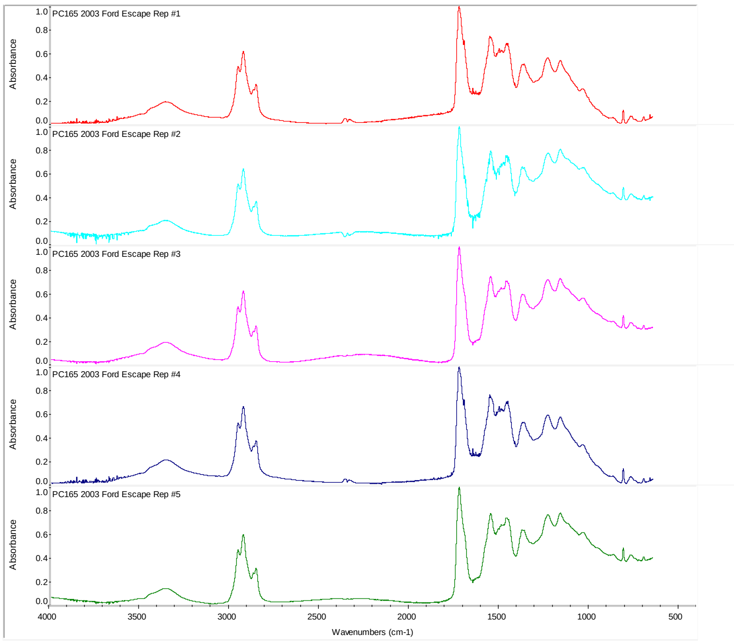
Title: PC165 2003 Ford Escape

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



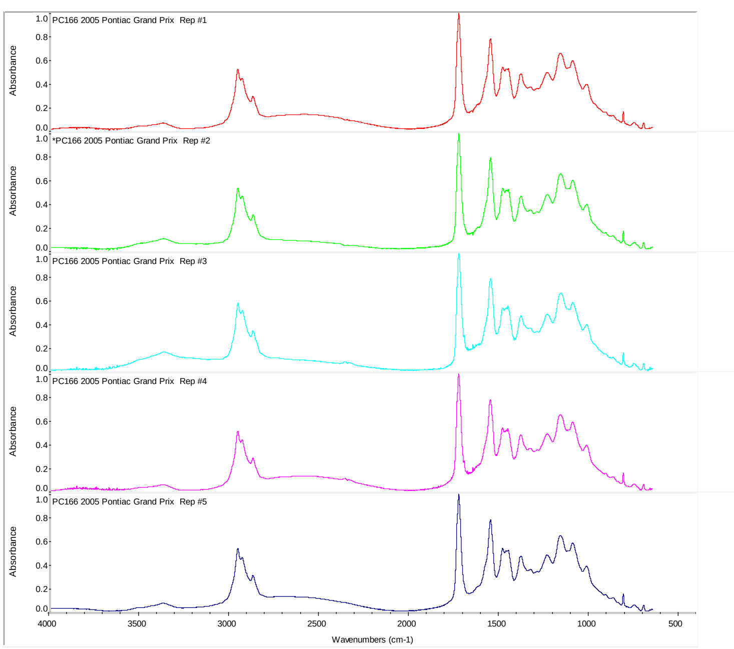
Title: PC166 2005 Pontiac Grand Prix

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



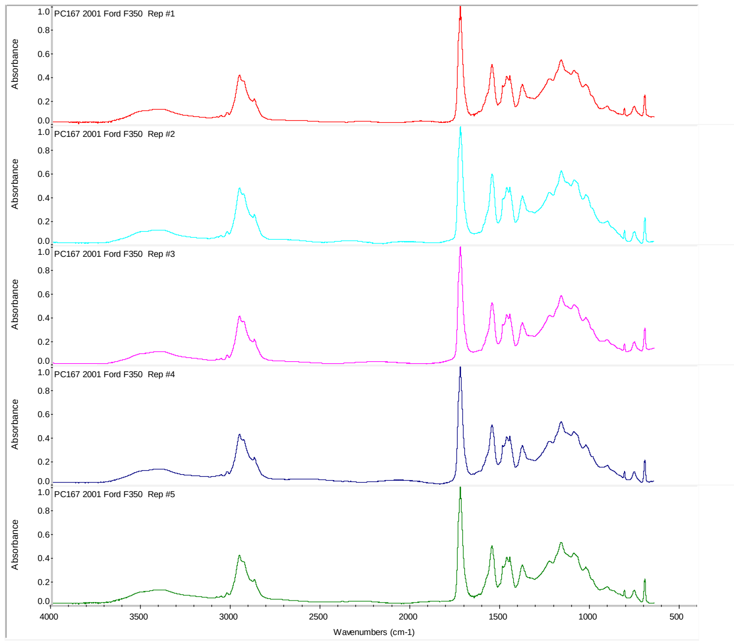
Title: PC167 2001 Ford F350

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



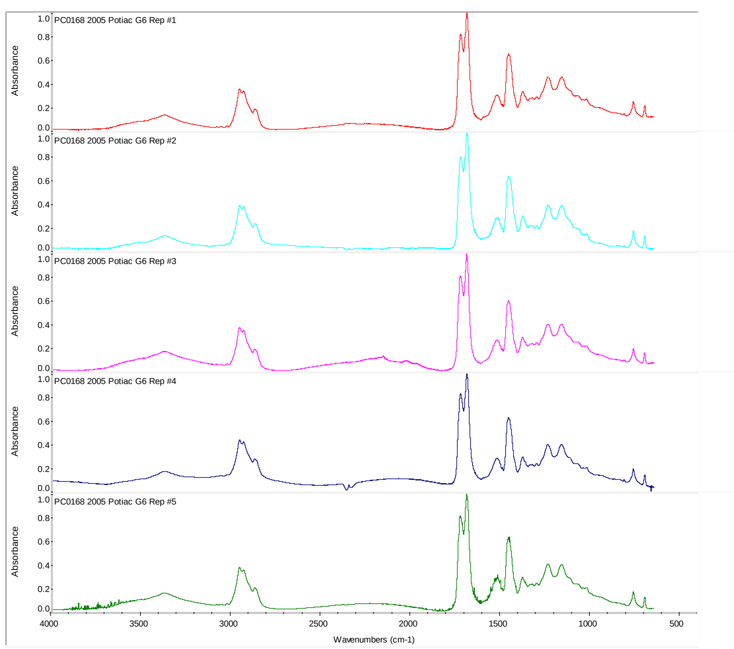
Title: PC0168 2005 Potiac G6

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



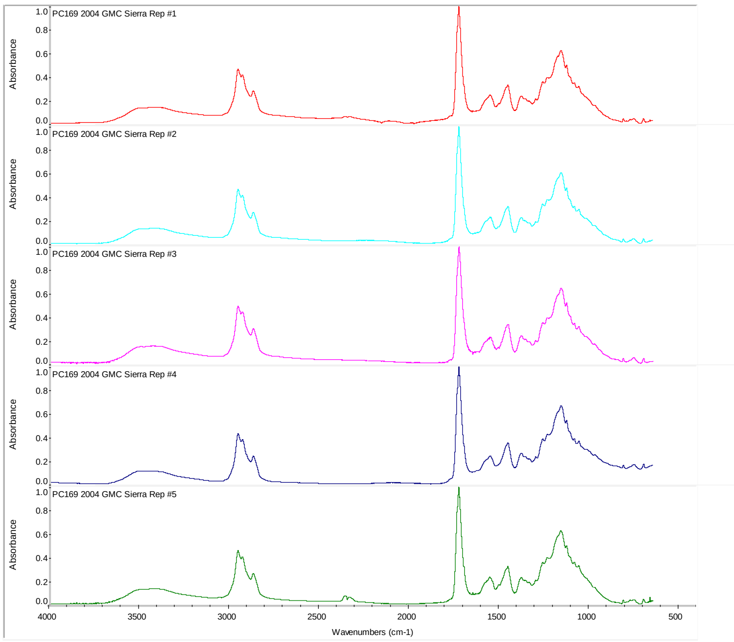
Title: PC169 2004 GMC Sierra

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



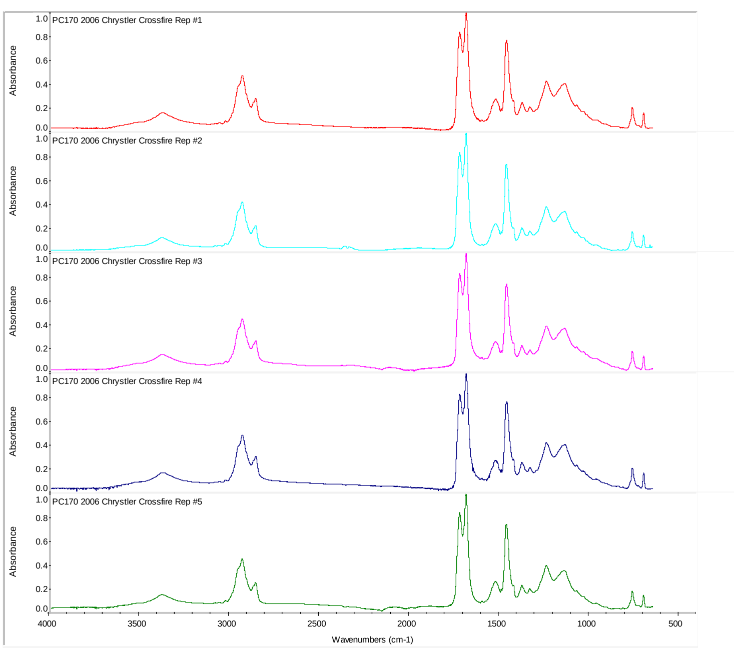
Title: PC170 2006 Chrystler Crossfire

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



Title: PC171 1999 Chevy Blazer

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:

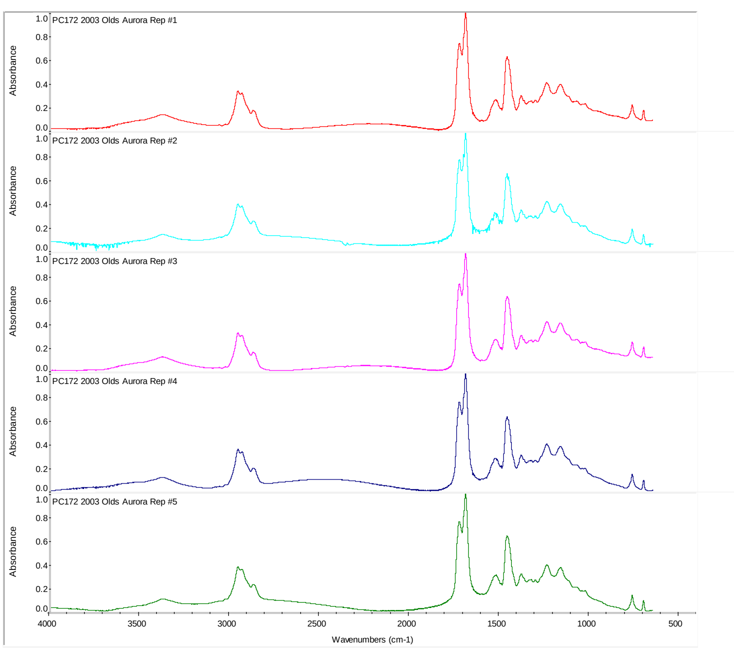
Title: PC172 2003 Olds Aurora

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



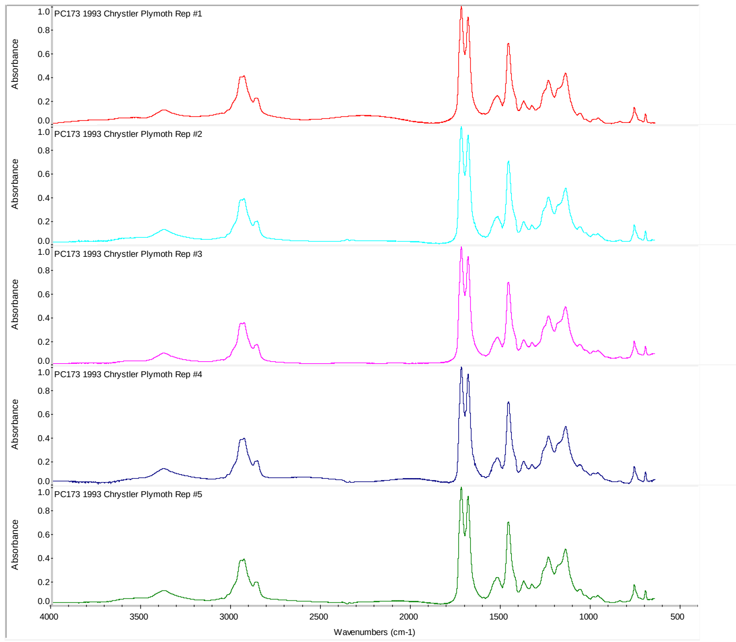
Title: PC173 1993 Chrystler Plymoth

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



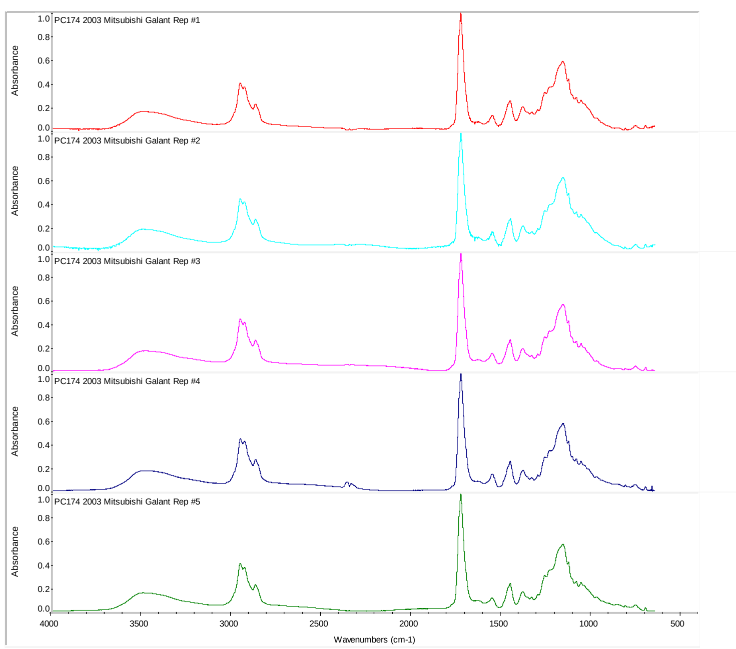
Title: PC174 2003 Mitsubishi Galant

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



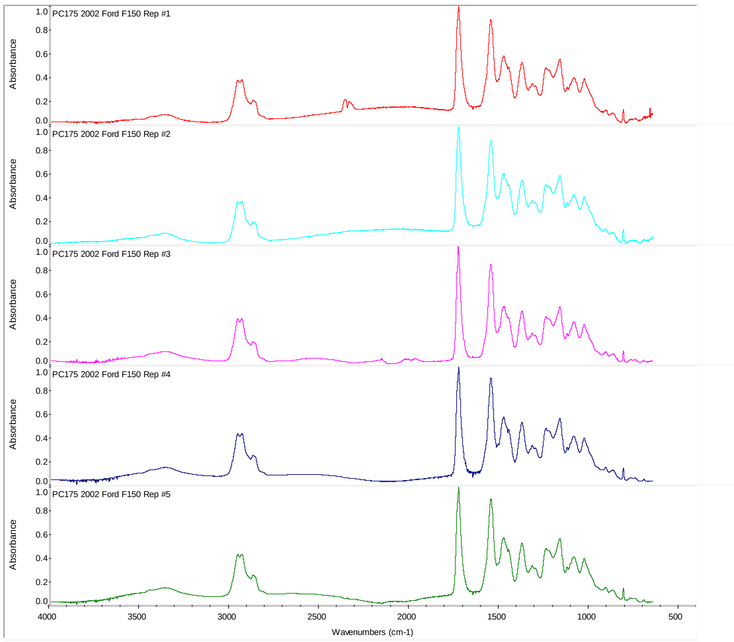
Title: PC175 2002 Ford F150

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



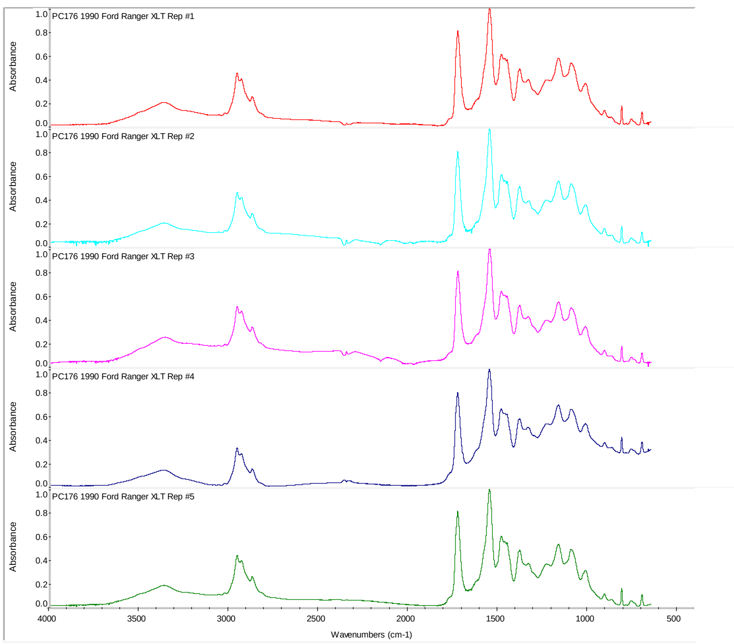
Title: PC176 1990 Ford Ranger XLT

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



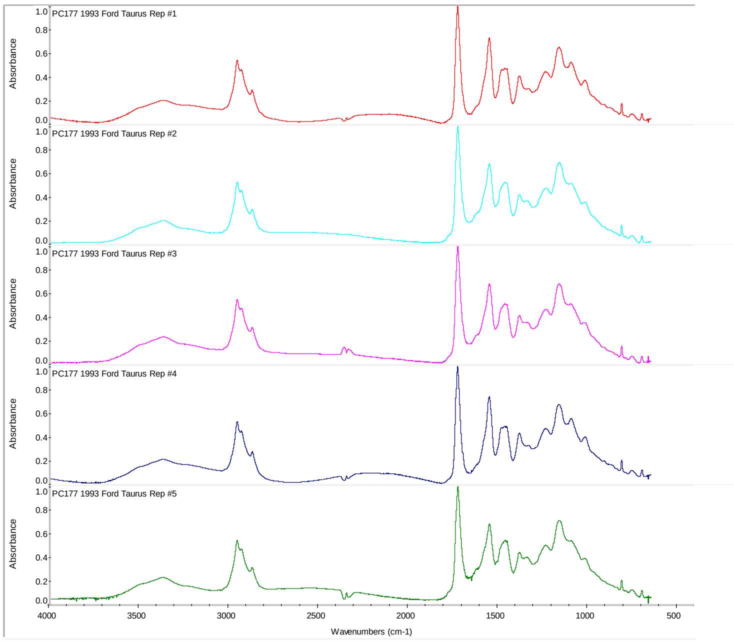
Title: PC177 1993 Ford Taurus

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



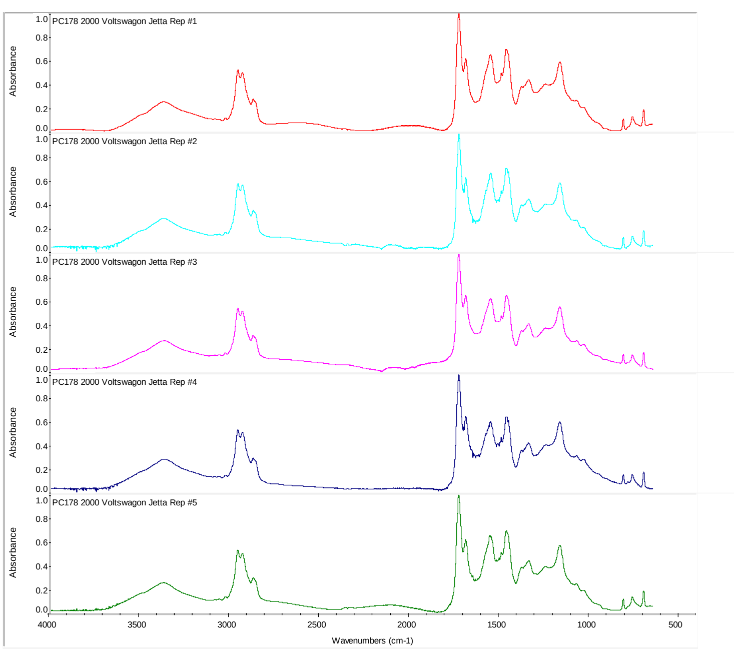
Title: PC178 2000 Voltswagon Jetta

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



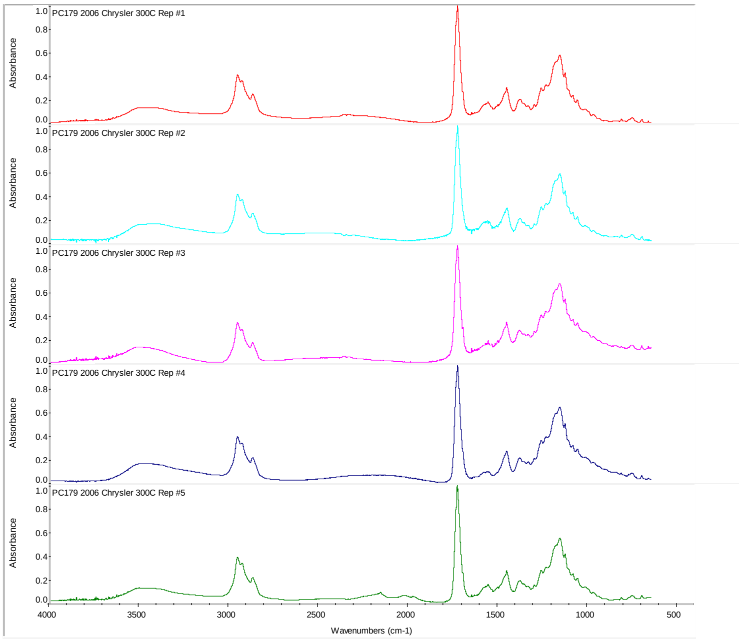
Title: PC179 2006 Chrysler 300C

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



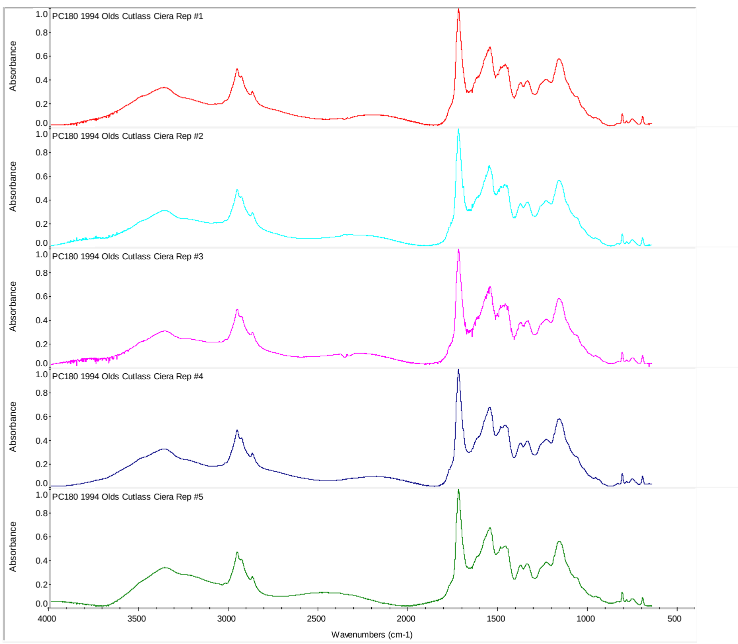
Title: PC180 1994 Olds Cutlass Ciera

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



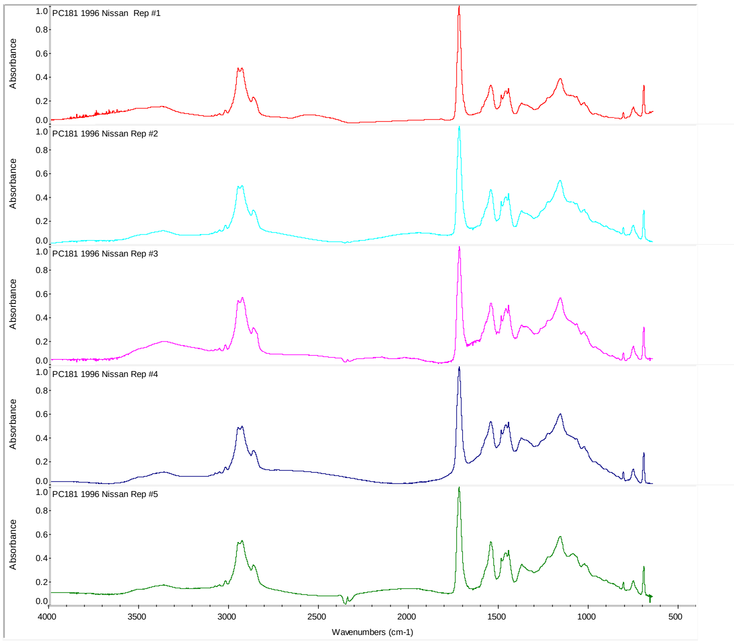
Title: PC181 1996 Nissan

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



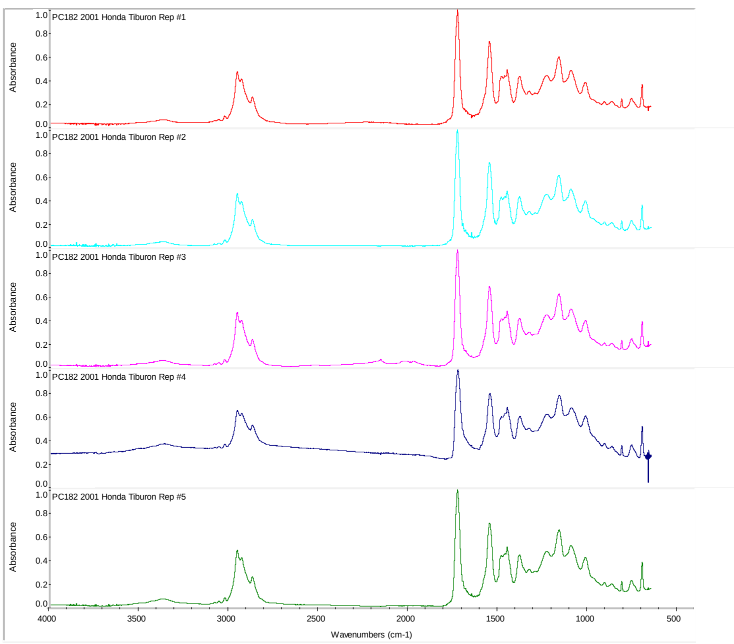
Title: PC182 2001 Honda Tiburon

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



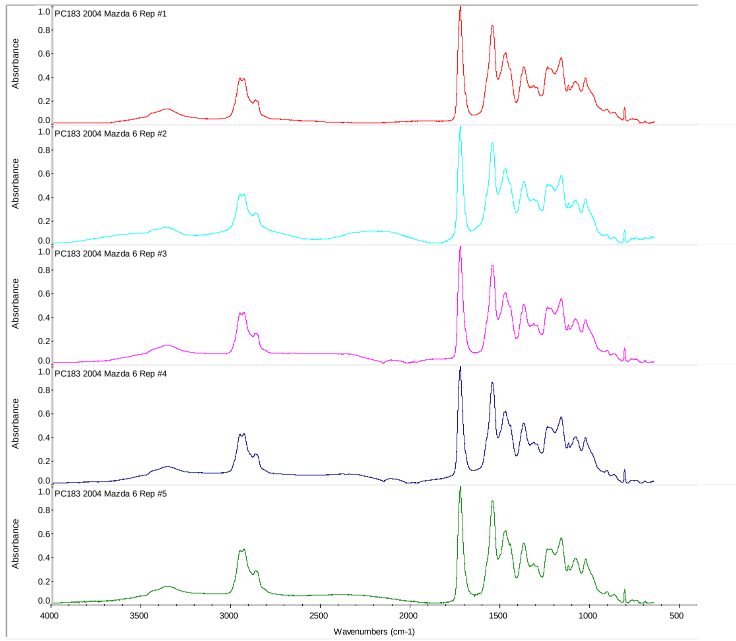
Title: PC183 2004 Mazda 6

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



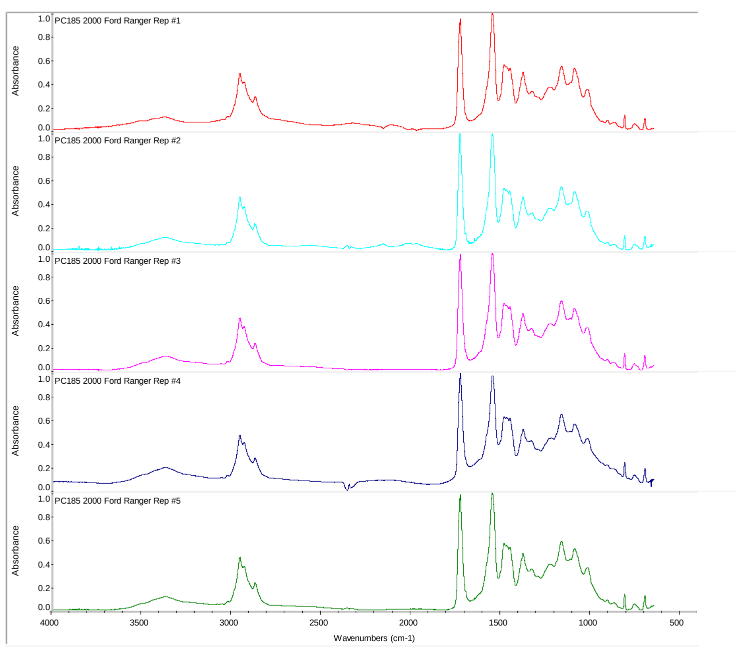
Title: PC185 2000 Ford Ranger

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



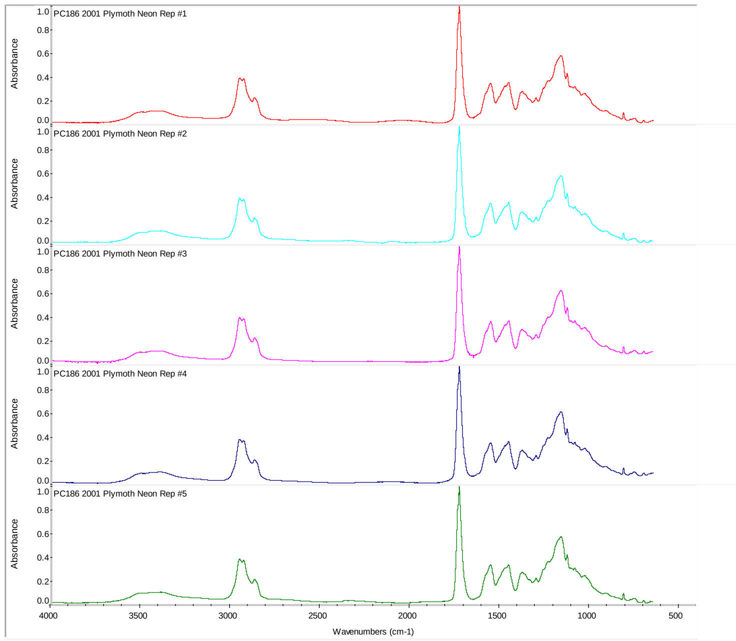
Title: PC186 2001 Plymoth Neon

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



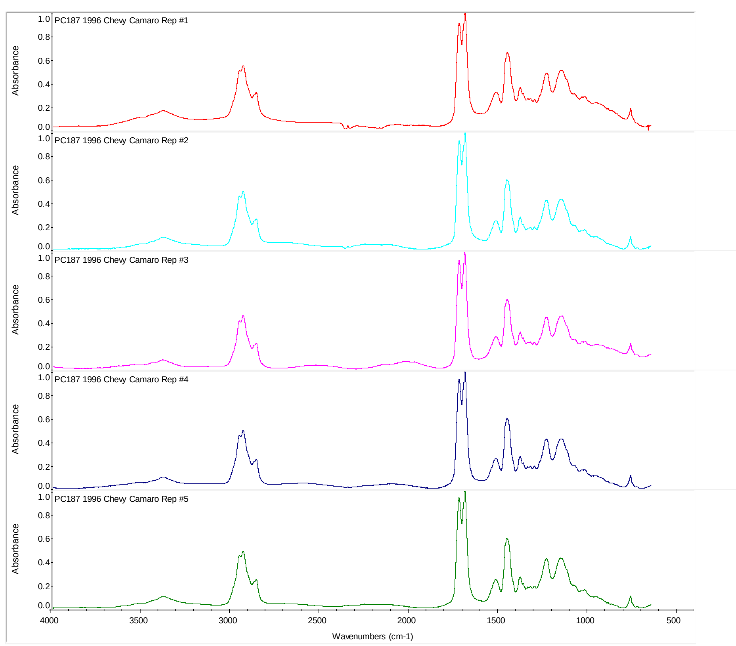
Title: PC187 1996 Chevy Camaro

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



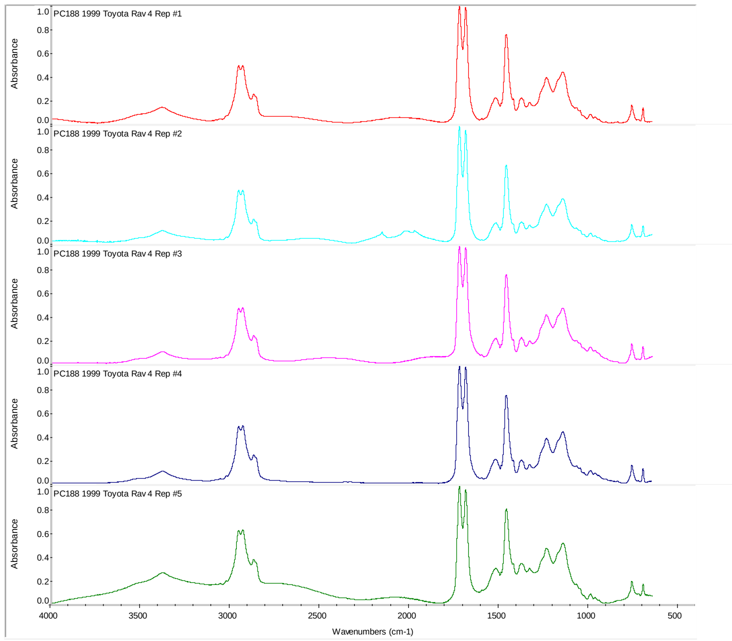
Title: PC188 1999 Toyota Rav 4

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



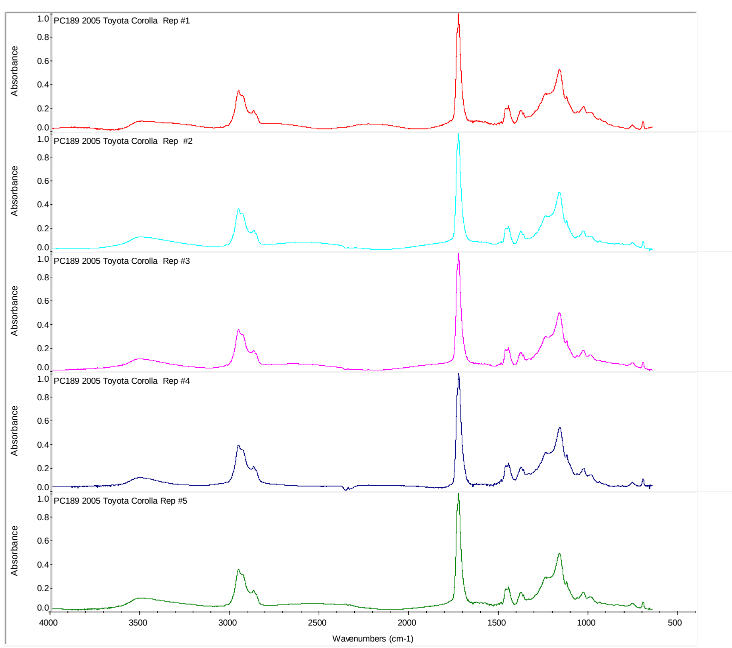
Title: PC189 2005 Toyota Corolla

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



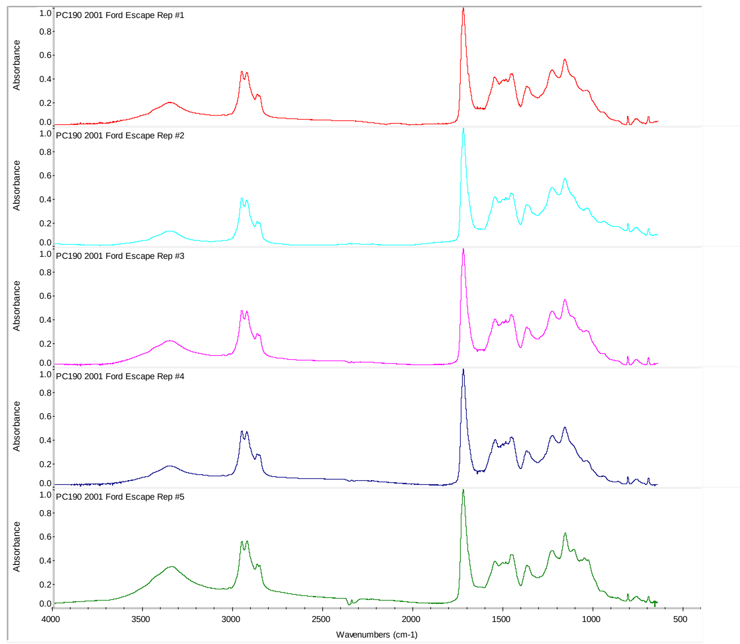
Title: PC190 2001 Ford Escape

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



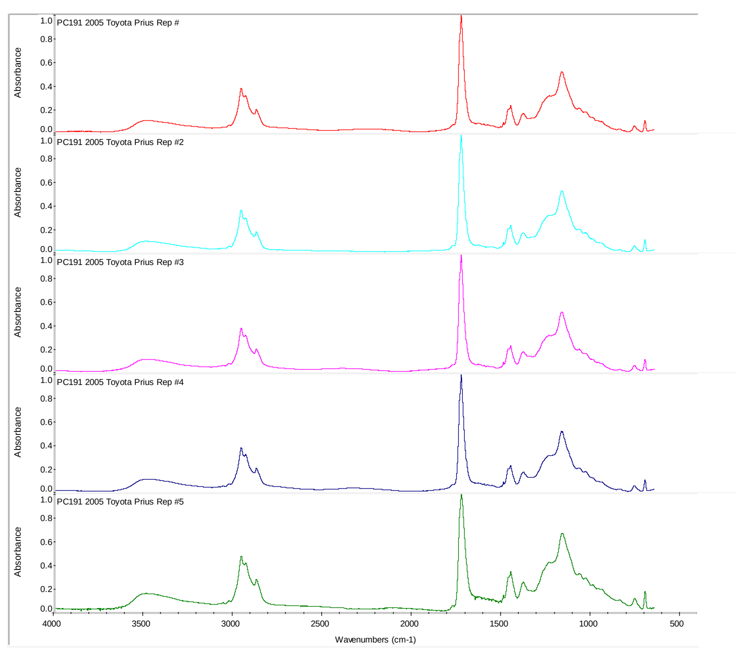
Title: PC191 2005 Toyota Prius

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



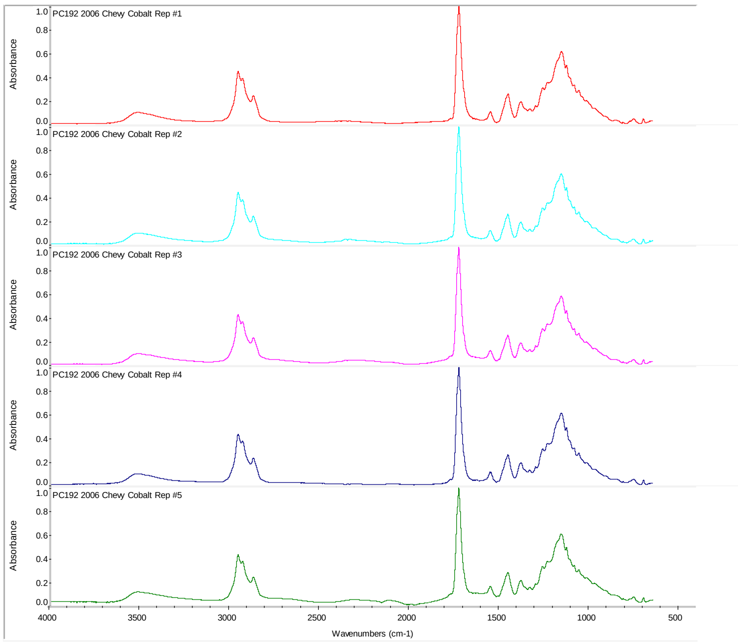
Title: PC192 2006 Chevy Cobalt

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



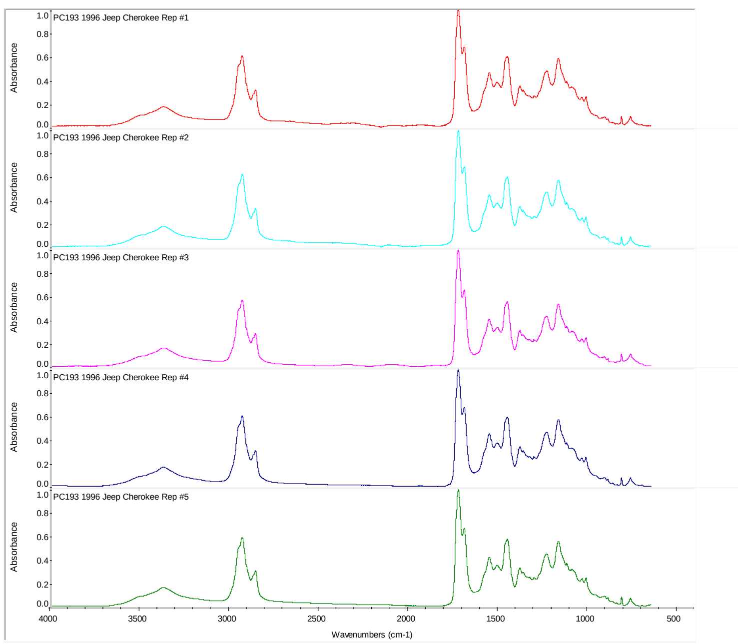
Title: PC193 1996 Jeep Cherokee

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 4.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



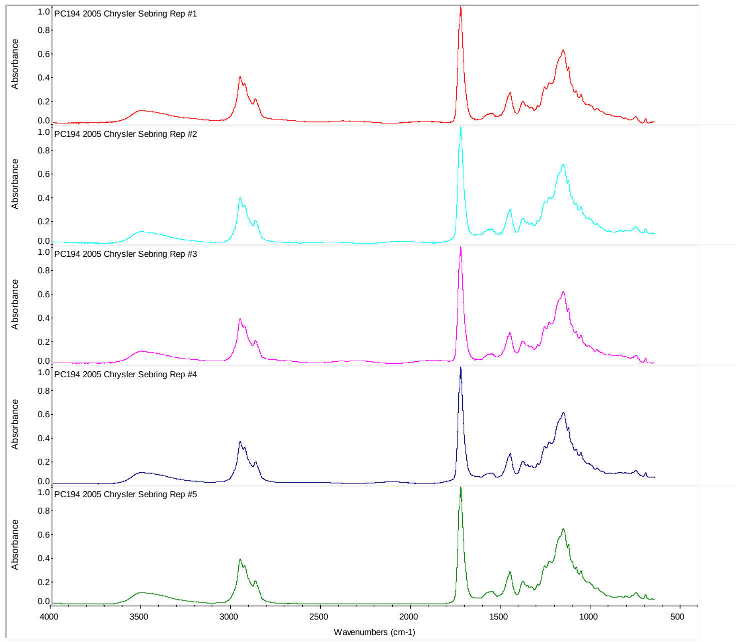
Title: PC194 2005 Chrysler Sebring

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



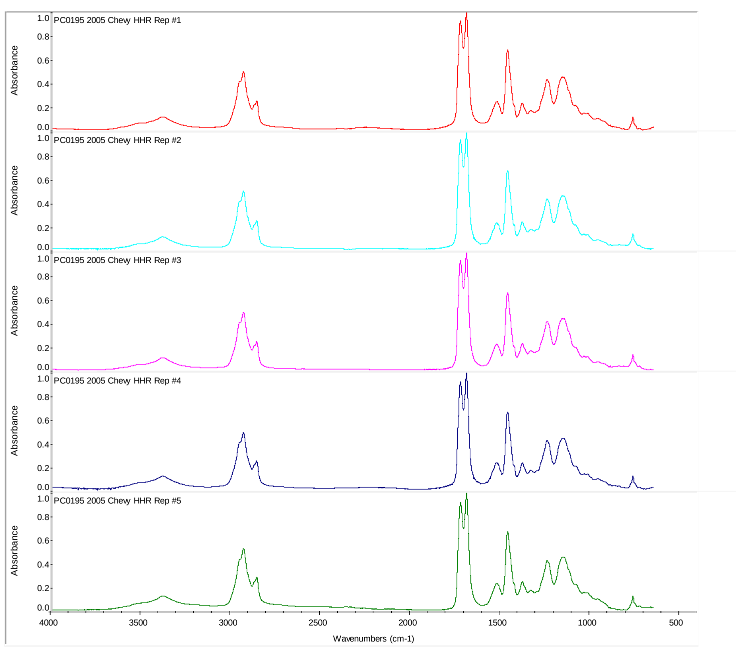
Title: PC0195 2005 Chevy HHR

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



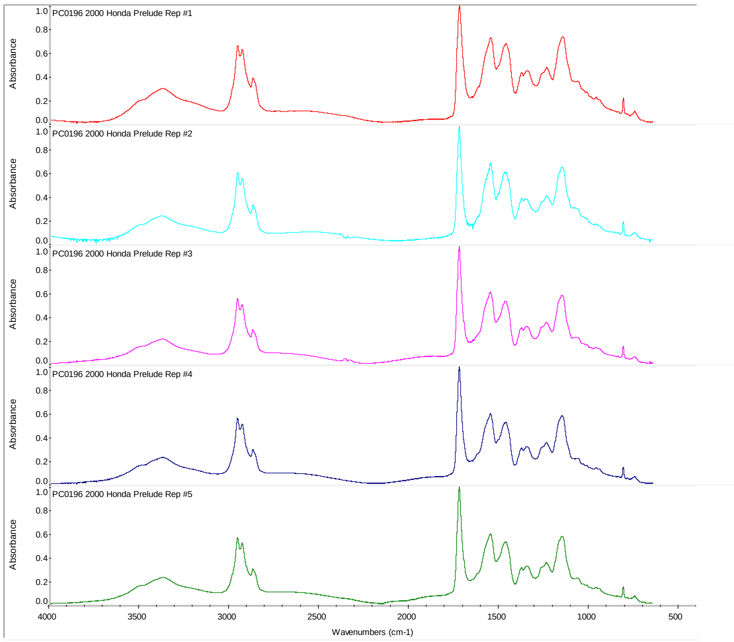
Title: PC0196 2000 Honda Prelude

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:
Interesting to note that the pigment used on what was Honda's sports car bled into the clear coat and that the clear coat flakes apart when working with it.



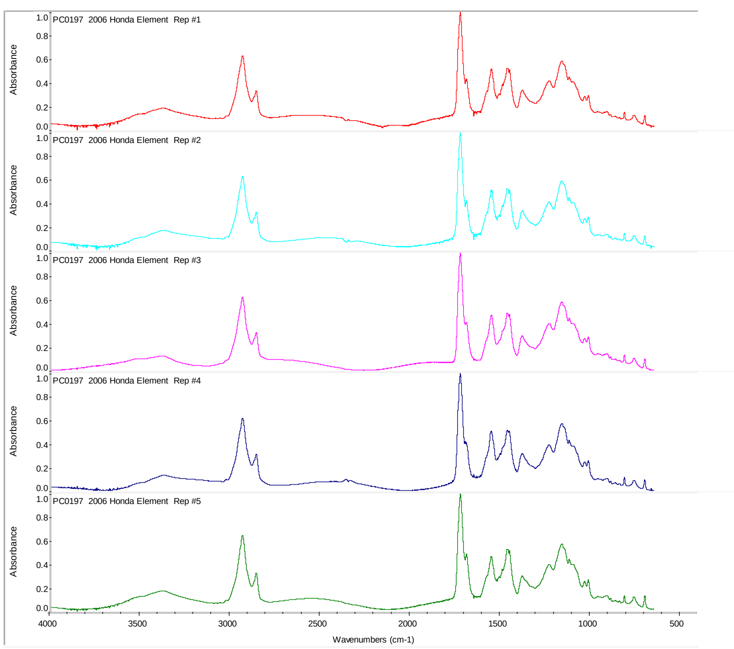
Title: PC0197 2006 Honda Element

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



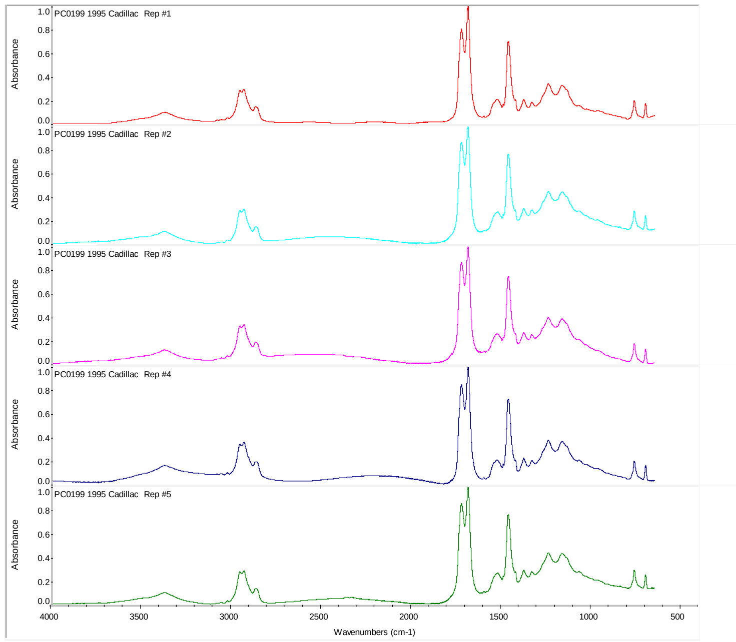
Title: PC0199 1995 Cadillac

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



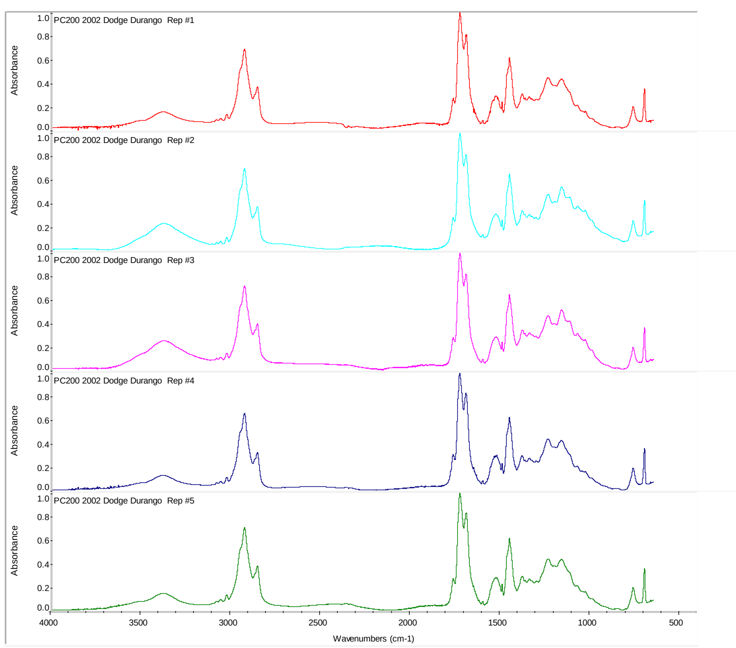
Title: PC200 2002 Dodge Durango

Analyst: James D. Osborne

Number of sample scans: 128
Number of background scans: 128
Resolution: 4.000
Sample gain: 2.0
Optical velocity: 1.8988
Aperture: 100.00

Detector: MCT/A
Beamsplitter: KBr
Source: IR

Comment:



Appendix B Macro Program for Data Processing